REPORT

OF THE

SECRETARY OF WAR;

BEING PART OF

THE MESSAGE AND DOCUMENTS

COMMUNICATED TO THE

TWO HOUSES OF CONGRESS

AT THE

BEGINNING OF THE SECOND SESSION OF THE FORTY-FOURTH CONGRESS.

VOLUME II.

PART III.

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APPENDIXES

TO THE

REPORT OF THE CHIEF OF ENGINEERS.

(CONTINUED.)

APPENDIXES

TO THE

REPORT OF THE CHIEF OF ENGINEERS,

(CONTINUED.)

APPENDIX H H.

ANNUAL REPORT OF MAJOR C. B. COMSTOCK, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

SURVEY OF THE NORTHERN AND NORTHWESTERN LAKES.

UNITED STATES LAKE SURVEY OFFICE,
Detroit, Mich., July 10, 1876.

GENERAL: I have the honor to submit the report of the survey of the northern and northwestern lakes for the fiscal year ending June 30, 1876.

LAKE ONTARIO.

At the date of my last annual report, the angles of the primary triangulation had been read as far west as Palmyra, and a site for a base-line near Buffalo had been selected. During the year, the primary triangulation along the lake has been completed by parties in charge of Assistant Engineers Wisner, Woodward, Russell, Darling, and Metcalf. The Buffalo primary base has been measured with the Bache-Würdemann apparatus by Assistant Engineer E. S. Wheeler.

Latitude and azimuth have been carefully observed at station Tonawanda by Assistant Engineer Wisner, and the longitudes of station Tonawanda and of station Mannsville at east end of Lake Ontario have been determined telegraphically by Lieutenant Lockwood at Detroit and Assistant Engineer Flint in the field. The results will be found in Appendixes B and I.

On June 30, 1875, the topography and hydrography of the American shore of the lake had been carried west to the vicinity of Olcott. The topography and inshore hydrography have now been carried westward to Port Dalhousie, completing it by the parties in charge of Assistant Engineers Eisenmann, Towar, Terry, Mayer, and Lamson. The off-shore hydrography has been completed by Captain Adams and Lieutenant Powell, in charge, respectively, of the steamers Ada and Surveyor, thus completing the work on this lake.

NIAGARA RIVER.

On completing the topography of Lake Ontario in July, 1875, the parties of Assistant Engineers Towar, Terry, and Lamson were transferred

to the Niagara River, and completed the topography of both banks of the river, (including a detailed survey of Niagara Falls,) and the hydrography where the currents were such as make it practicable to sound. The detail sheet, including Niagara Falls, has been photolithographed.

This work having been completed, the topographical parties were transferred to Lake Erie.

LAKE ERIE.

Assistant Engineer Marr continued the reconnaissance for primary triangulation from Buffalo west, along Lake Erie and its south shore, to the vicinity of Cleveland, locating the stations, which have been built as far west as Conneaut. The parties of Assistant Engineers Wisner, Woodward, Marr, Darling, and Russell have read the angles of the primary triangulation west to the vicinity of Westfield, reading here, as along Lake Ontario, also the angles of secondary triangles, to locate intermediate points along the shore.

The topography and inshore hydrography have been carried west to Port Colborne, adopted as a limit on the north shore, and to the vicinity of Ashtabula, Ohio, on the south shore, by the parties of Assistant Engineers Eisenmann, Towar, Terry, Wagner, and Lamson.

The offshore hydrography has made the same progress in the hands of Captain Adams and Lieutenant Powell on the steamers Ada and Surveyor, in the fall of 1875, and Lieutenant Price on the steamer Ada, in June, 1876.

Parties were withdrawn from the field about October 15, 1875, and, on account of the reduction in the appropriation for the year, did not take the field this spring till early in June.

As no appropriation had been made by June 25, 1876, to continue the works, to avoid violation of law it became necessary to withdraw all parties from the field.

STATE OF MICHIGAN.

The determination of points in the interior of Michigan in aid of the State survey has been continued, latitudes being observed with a zenith-telescope, and longitudes being determined by telegraphic connection with the Lake-Survey observatory at Detroit. Lieutenant Lockwood observed at Detroit and Lieutenants Price and Bailey in the field. The following points were occupied: Charlotte, Marshall, Kalamazoo, Paw Paw, Stanton, Howell, Lansing, Jackson, Hastings, Allegan, Newaygo.

Assistant Engineer Flint has carried a reconnaissance for a triangulation to connect the triangulation of Lake Michigan with that of Lake Erie about 100 miles east from the south end of Lake Michigan, and the stations have been built as far as Mungo. He also made a reconnaissance for the continuation of the triangulation south from Chicago.

MISCELLANEOUS.

The progress of the harbor of refuge at Sand Beach, Lake Huron, to a point at which it became valuable to commerce, gave rise to repeated demands for a chart in detail of that harbor. Assistant Engineer Morrow was accordingly directed to make a detailed survey of it in August, 1875. The work was completed, and the resulting map has been photolithographed.

At the request of Lieutenant Hoffman, acting engineer officer of the Department of Texas, signals for the telegraphic longitudes of Forts Griffin and Richardson, Texas, have been exchanged with him.

Detroit time has been given to Capt. W. S. Stanton, United States Engineers, at Omaha.

The heights of the great lakes above the ocean are very important in reference to the hypsometry of all the vast area in their vicinity, and there has been a good deal of uncertainty as to their values. It was accordingly decided to undertake their determination. The Coast Survey have determined the height of a bench-mark at Greenbush, N. Y., above mean tide at New York City, and this was taken as a point of departure. Duplicate lines of levels were run from it to a bench-mark at Oswego, N. Y., connected with a tide-gauge there, and from a bench-mark connected with a tide-guage at Port Dalhousie, along the Welland Railway, to a bench-mark and tide-gauge at Port Colborne. A bench-mark and tide-gauge were also established at the mouth of the Detroit River, at Gibraltar and Rockwood respectively.

The difference of level between the bench-marks at Oswego and Port Dalhousie and between those at Port Colborne and Gibraltar was obtained by careful observations of the gauges from May 19 to August 31, 1875; the mean surface of the lakes during this period being taken as level. It was feared that a considerable error might exist in this assumption from a preponderance of winds in one direction. The maximum effect of wind in producing difference of level at its ends would arise when the wind had the direction of the axis of the lake, and its minimum when at right angles to the axis.

On grouping the gauge-observations with reference to the directions of the winds, it was found that on Lake Ontario the winds blowing nearly in the direction of the lake gave a difference of level between bench-marks at Oswego and Port Dalhousie differing by about 0.04 foot from that when the winds blew at right angles to the lake, but that the mean difference of level for all winds is very nearly the same as for winds at right angles to the lake; showing that the wind effect on the mean level of the lake is well eliminated. The same is true for Lake Erie, although there winds in the general direction of the axis give a difference of level between bench-marks at Port Colborne and Gibraltar differing by about 0.2 foot from that when winds are nearly at right angles to the lake.

The leveling was done independently by Assistant Engineers L. L. Wheeler and Lehnartz, whose report, with details, will be found in Appendix F. The resulting height of mean level of Lake Ontario from 1860 to 1875 inclusive, above mean tide at New York, is 247.25 feet, with a probable error of ±0.35 foot, while the same quantity for Lake Erie is 573.58 feet, with a probable error of ±0.35.

The following table gives a *résumé* of the field-work done between May 1, 1875, and May 1, 1876:

Longitudes determined telegraphically	13
Latitudes determined	12
Primary azimuth	1
Primary-triangulation stations occupied	34
Primary base-line measured	1
Miles of developed shore-line	580
Square miles of topography	321
Square miles of inshore hydrography	324
Square miles of offshore hydrography	2,850
Sheets of topography and in-shore hydrography plotted during winter	57
Sheets of off-shore hydrography	11
Lines of deep-sea soundings on Lake Ontario	11
Miles of leveling in duplicate	211

OFFICE WORK.

During the winter, the field-notes of the topographical work of last summer have been plotted on fifty-seven sheets of antiquarian paper.

The off-shore hydrography has been plotted on eleven sheets.

Lieutenant Bailey's longitude and latitude work in connection with Lieutenant Lockwood, at Detroit, has been reduced, and his results are given in Appendix D.

Assistant Engineer Flint's longitude work in connection with Lieutenant Lockwood has been reduced, and that of Lieutenant Price in connection with Lieutenant Lockwood is also completed. Lieutenant Lockwood's results are given in Appendix B, and those of Lieutenant Price in Appendix C. The angles of the primary triangulation read during last summer have been reduced and tabulated. The adjustment of the triangulation from Lake Superior to Chicago has been completed, and that of the Lake Ontario triangulation is well advanced. The leveling by Assistant Engineers L. L. Wheeler and Lehnartz has been reduced.

Last year's observations for the expansion of the standard 15-foot brass bar of the Lake Survey for a temperature range from 32° F. to 89° F. have been reduced.

As Fizeau's determination of the co-efficient of expansion of brass shows that it depends on both the first and second powers of the temperature, a second determination of the expansion for a temperature-range from 32° F. to 62° F. has been made. The work has been partially reduced, and indicates that the mean expansion for 1° F. of the 15-foot brass bar between 32° and 62° F. is about one hundred thousandth part of an inch less than the mean expansion between 32 F. and 89 F. But this question cannot be fully determined till the thermometer-errors are precisely known.

The Lake-Survey thermometers, on which reliance has heretofore been placed, are those which have been compared either with the standard of the Ordnance Survey, or with that of the Kew observatory. Recent investigations by Recknagel and Bosscha, as well as the older ones of Regnault, show, in consequence of the expansion of glass and mercury depending on both the first and second powers of the temperature, that a mercurial thermometer which is correct at its fixed points, 32° F. and 212° F., may yet be in error at 100° F. by several tenths of a degree; and that, as the co-efficients of expansion of glass vary widely, no two mercurial thermometers, however carefully constructed, can be assumed in advance to give the same indications at points intermediate to the fixed points. Hence a standard of length whose standard temperature is fixed at 62° may have differing lengths as that temperature is determined by one or another mercurial thermometer.

An error of 0°.1 F. in the temperature of a brass standard yard affects its resulting length by about thirty-six one-millionths of an inch, an error much larger than those of good comparisons. Such errors also affect precise determinations of the co-efficients of expansion of standards.

The natural method of avoiding this difficulty is to refer, by comparisons, all mercurial thermometers to an air-thermometer, thus detecting their errors. Accordingly, measures have been taken to have one of the Lake-Survey standard thermometers compared with an air-thermometer.

Professor Wild, of the St. Petersburg observatory, gives the following results of a single comparison of Kew standard thermometer No. 495:

Temperatures:	0°C.	10°C.	18°.3C.	23°.9C.	40°.6C.
Correction to No. 495:	0°.00	+ 0°.10C.	+ 0°.16C.	+ 0°.19C.	+ 0°.30C.

The length of Lake-Survey brass standard yard No. 8 having decreased, in consequence perhaps of imperfect firmness of the agates which form its end surfaces, the yard was heated to about 130° F., and the agates

were then subjected to a pressure of 30 or 40 pounds, to force them inwards; then the brass was burnished down around the agates by an equal pressure. This was done on August 2, 1875. Numerous comparisons were made to determine its new value in terms of the other yards. No change in the lengths of Nos. 6, 7, 9, 10 was detected.

Additional comparisons of Nos. 6 and 7 have also been made with the Clarke yards A and B.

As soon as the errors of the Lake-Survey mercurial thermometers with reference to an air-thermometer are known, values for the lengths of the standard yards and the 15-foot brass bar, in terms of Clarke yards A and B, as well as for their co-efficients of expansion, can be adopted. Then values for the base-lines thus far measured can be adopted.

Lieut. Col. A. R. Clarke, Royal Engineers, of the Ordnance Survey, has, in addition to the many favors previously rendered to the Lake Survey, compared a standard inch constructed for the Lake Survey by Simms with the Ordnance-Survey standard. The resulting values of its subdivisions are given in Appendix G.

The angles measured with the 12-inch Troughton and Simms theodolite having indicated the existence of periodic error in its graduation, it was deemed best to examine it carefully. Assistant Engineer Woodward did so, and his results are given in Appendix E.

As of interest to those engaged in similar work, I have had some notes prepared by Captain Adams, on the methods in topography and hydrography of the Lake Survey. They are given in Appendix A.

During the year, Mr. Mueller has completed the reduction from the detail sheets of the chart of south end of Lake Michigan on a scale of $\frac{1}{400000}$, and has begun a chart of Lake Ontario on the same scale. Mr. Molitor has nearly completed a chart of Detroit River, scale $\frac{1}{40000}$.

Mr. Fisher has completed chart No. 4 of the Saint Lawrence River, scale $\frac{1}{30000}$, and made progress on coast-chart No. 3 of Lake Michigan, scale $\frac{1}{80000}$. Mr. Witzleben has completed chart No. 3 of Saint Lawrence River, scale $\frac{1}{30000}$; a chart of harbor of refuge at Sand Beach, scale $\frac{1}{8000}$, and begun coast-chart No. 1 of Lake Ontario, scale $\frac{1}{80000}$. Mr. Wansleben has completed chart No. 5 of the Saint Lawrence River, scale $\frac{1}{30000}$. Mr. Franke has made progress on chart No. 6, Saint Lawrence River, scale $\frac{1}{30000}$.

Water level observations have been continued at Sault Sainte Marie, Marquette, Escanaba, Milwaukee, Port Austin, Cleveland, Erie, Charlotte, and Sackett's Harbor.

The question of the absolute heights of the lakes above mean tide at New York having been taken up, that of their fluctuation was important. Accordingly, the observations of the Lake Survey were re-reduced, and wherever satisfactory checks on their accuracy could be obtained from another station, showing that there had been no disturbance of tide-gauge zero, the monthly mean heights have been plotted with the time as abscissa. The period covered is from 1859 to 1876, except for Lake Superior. The results are given in Appendix H. I am much indebted to Maj. J. M. Wilson, United States Engineers, for water-level observations at Oswego, N. Y.; to Prof. G. T. Kingston for observations at Toronto, Ontario; to E. V. Bodwell, esq., superintendent Welland Canal, for observations at Port Colborne; and to W. H. Clark, esq., assistant city engineer, for observations at Chicago.

A table of geographical positions along the Saint Lawrence River is given in Appendix K. Many of the points are triangulation-stations, but even these may be of service so long as the wooden stations stand, either in finding the latitudes and longitudes of points near them, or in

determining the variation of the magnetic needle by means of the true azimuths given in the table.

Meteorological observations have been continued at Port Austin and Monroe, Mich., and at Sackett's Harbor, N. Y. The results for 1874 and 1875 are given in Appendix L.

In Appendix M are given the details of work by chiefs of the different parties.

A list of published charts of the Lake Survey and of the annual issue for several years is given in Appendix N.

Four sketches are forwarded herewith, showing the general progress of the Lake Survey, and of the triangulation in the vicinity of Lakes Michigan, Ontario, and Erie respectively.

Numerous manuscripts, books, and maps relating to European surveys were sent to me by the Engineer Department in 1875 and 1876 for examination and report. They were carefully looked over; abstracts were made of such as were deemed most important, and these were, from time to time, forwarded to the Engineer Department for its use. Subsequently, it was deemed advisable to print them, that their information might become more generally available. It should be remembered that they are mainly memoranda for those familiar with such work, derived from the data at hand. Considered as accounts of surveys in different countries, they necessarily have many imperfections.

The following officers have been under my command during the past year: Capt. H. M. Adams, Corps of Engineers; First Lieut. D. W. Lockwood, Corps of Engineers; First Lieut. C. F. Powell, Corps of Engineers; First Lieut. P. M. Price, Corps of Engineers; Second Lieut. T. N. Bailey, Corps of Engineers. I am indebted to them and to the assistant engineers of the Lake Survey for hearty co-operation in its work.

Estimate of funds for continuance of the survey of the northern and northwestern lakes and Mississippi River for the fiscal year ending June 30, 1878.

For continuing survey of Lake Erie; for determination of points in aid of State surveys and construction of maps; for continuation of triangulation south from Chicago and east to connect with Lake Erie; for survey of Mississippi River; and miscellaneous	$212,000

Details as follows:

Lake Erie.

Completion of topography, four parties	$40,000
Completion of triangulation, four parties	27,500
Completion of hydrography, (one steamer party,) and construction of maps	9,500

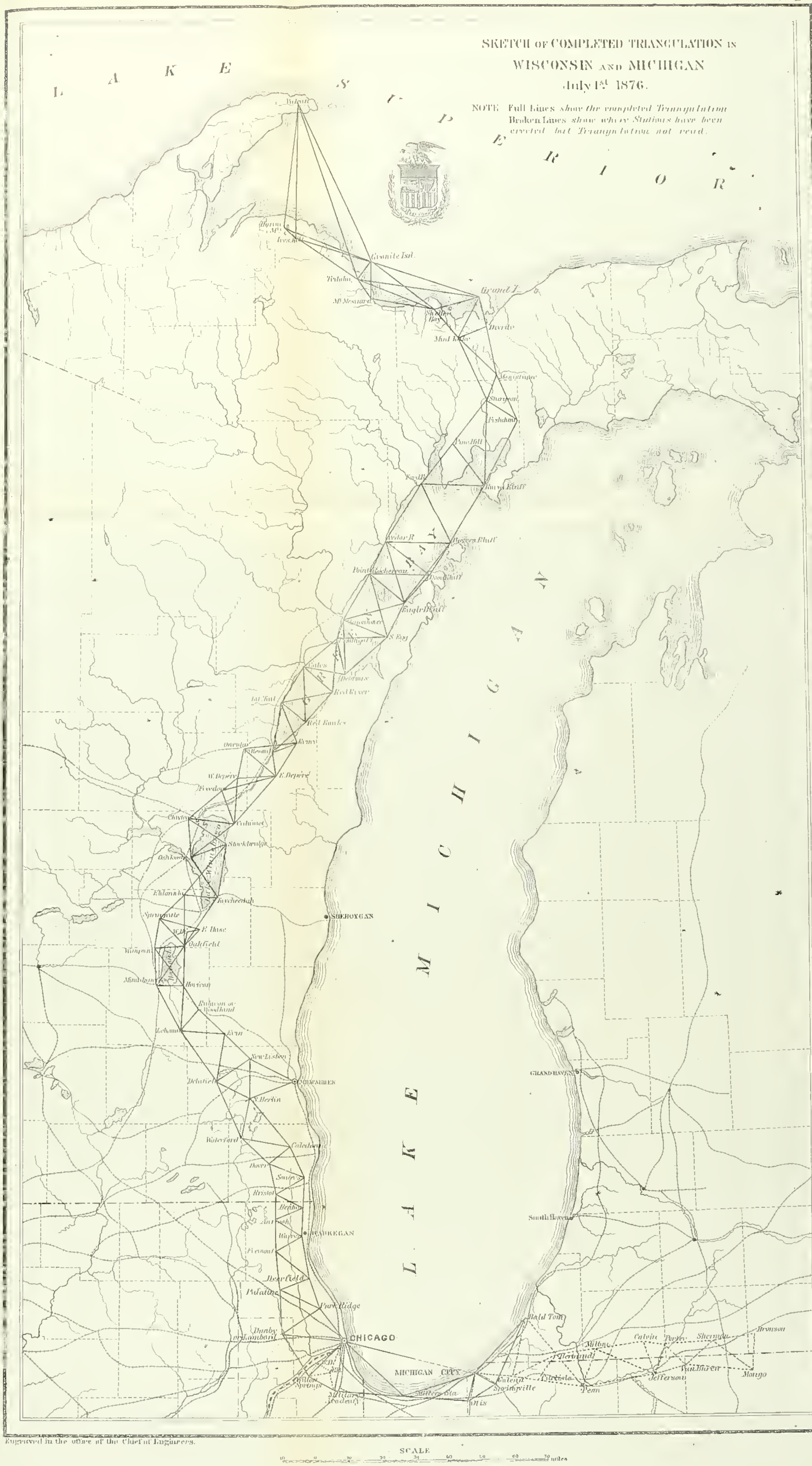
Lake Ontario.

Construction and engraving of maps	8,000

Lake Michigan.

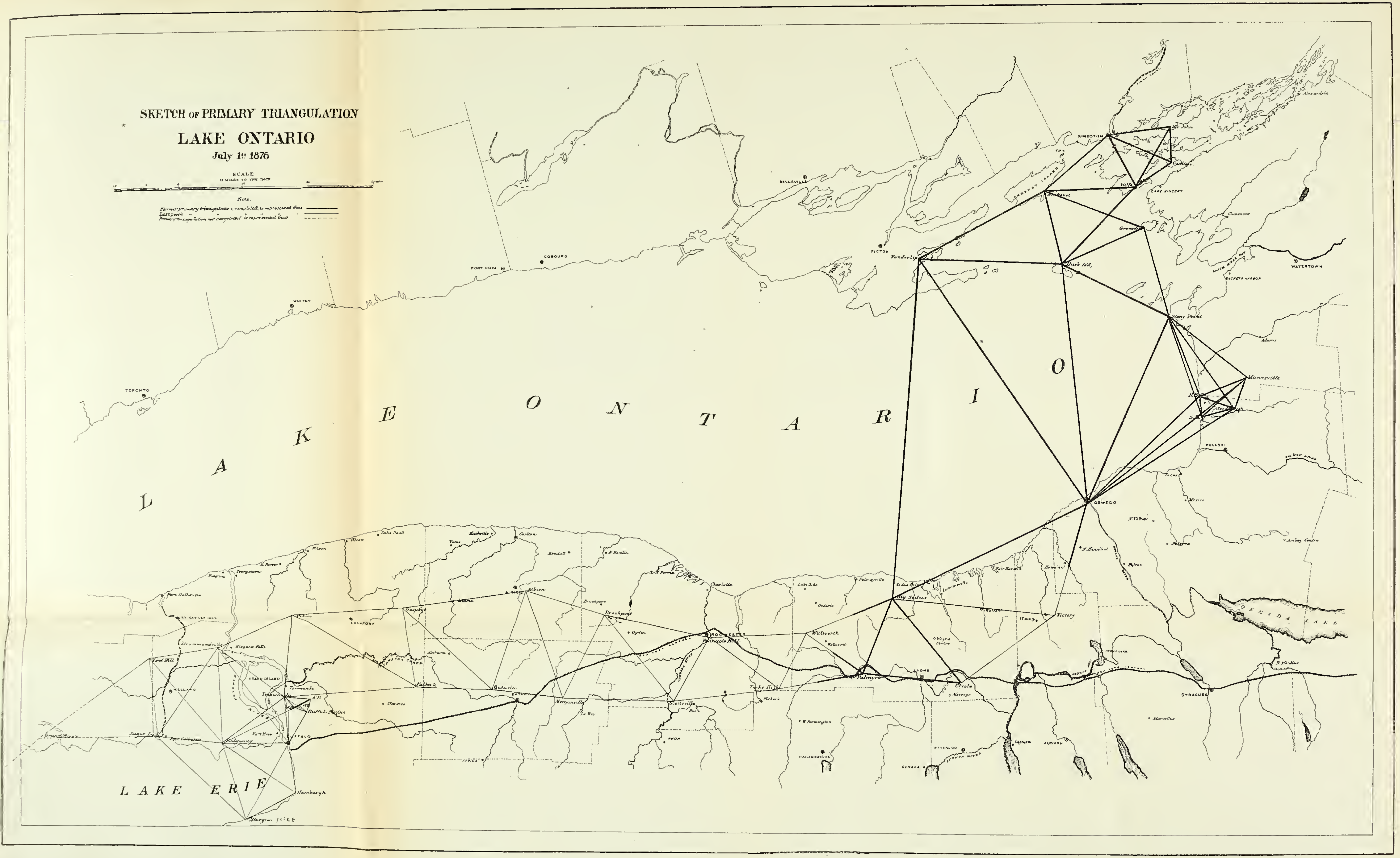
Continuation of triangulation east from Mungo and south from Chicago, four triangulation parties; and construction of maps	27,000

Engraved in the Office of the Chief of Engineers.



Engraved in the office of the Chief of Engineers.

SCALE


SKETCH OF PRIMARY TRIANGULATION
LAKE ONTARIO
July 1st 1876
SCALE
Note.
Former primary triangulation, completed, is represented thus
LAKE ONTARIO
LAKE ERIE
ONEIDA LAKE
KINGSTON
BELLEVILLE
PICTON
COBOURG
PORT HOPE
WHITBY
TORONTO
Vanderlip
Duck Isl.
Grenadier
Amherst
Wolfe
Cape Vincent
Stony Point
Mannsville
Sandy
Adams
Pulaski
Watertown
Sackets Harbor
Chaumont
Alexandria
OSWEGO
SYRACUSE
Victory
Big Sodus
Walworth
Palmyra
Clyde
Lyons
ROCHESTER
Pinnacle Hill
Charlotte
Brockport
Albion
Carlton
Batavia
Morganville
Scottsville
Turks Hill
Fishers
Canandaigua
Geneva
Waterloo
Auburn
Marcellus
Avon
Le Roy
Gaspbrt
Falkirk
Lockport
Tonawanda
Grand Island
Buffalo Plains
Buffalo
Fort Erie
Niagara Falls
Drummondville
Lewiston
Youngstown
Wilson
Olcott
Port Dalhousie
St Catharines
Welland
Port Colborne
Sugar Loaf
Grand River
Hamburgh
Sturgeon Point
Oswego
Hannibal
N. Hannibal
Fulton


SKETCH OF PRIMARY TRIANGULATION
LAKE ERIE
July 1st. 1876.
SCALE 1/500,000
SCALE OF MILES
10 0 10 20 30
Note
Triangulation completed is represented by full lines thus....
Triangulation not completed is represented by broken lines thus
Stations are built as far West as the line Claridon to Little Mountain
L A K E E R I E
DETROIT
TOLEDO
FREMONT
NORWALK
ELYRIA
CLEVELAND
PAINESVILLE
ASHTABULA
ERIE
DUNKIRK
BUFFALO
PORT CLINTON
SANDUSKY
MONROE
Huron River
Raisin River
Maumee River
Portage River
Vermillion River
Cuyahoga River
Grand River
Rockport
Royalton
Chester
Claridon
Warrensville
Little Mountain
Thompson
Andover
Orwell
Ellisboro
Westfield
Silver Creek
Sturgeon Point
Hamburg
Long Point
Houghton
Grand River
Sugarloaf
Ridgeway
M.C.R.R.
L.S.&M.S.R.R.
T.W.&W.R.R.
C.C.C.&I.R.R.
C.&P.R.R.
A.&J.R.R.
E.&P.R.R.

Survey of the Mississippi River.

Continuation of the triangulation, four parties; continuation of the topography, four parties; and construction of maps..	75,000

Miscellaneous.

For water-level observations, transportation of parties, and quarters and fuel for officers; for determination of points in aid of State surveys; for office-rent, fuel, stationery, instruments, and miscellaneous	25,000
Total...	212,000

Very respectfully, your obedient servant,

C. B. COMSTOCK,
Major of Engineers and Bvt. Brig. Gen.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

APPENDIX A.—TOPOGRAPHY AND HYDROGRAPHY.

REPORT OF CAPT. H. M. ADAMS, CORPS OF ENGINEERS, ON THE METHODS IN USE ON THE SURVEY OF THE LAKES.

For topography and inshore hydrography, the parties are distributed along the lake-shore at a distance of about 12 miles from each other, and each party is required to extend its work 6 miles on both sides, to connect with the work of the adjacent parties.

Topography is developed inland about ¾ of a mile; this distance being increased, when necessary, to include towns or important localities of any kind.

The inshore hydrography is extended lakeward ½ a mile, or to the 4-fathom curve.

From the primary triangulation, secondary points are determined for each of the above 12-mile sections, and the work done by a topographical party is connected with one or more of these points.

In the following description, the methods used for making the detailed survey of one of the 12-mile sections will be given.

Triangulation-stations (tertiary) are established from 500 to 2,000 meters apart, so as to include the area to be surveyed. These stations generally consist of a post about 8 inches diameter and 5 feet or 6 feet long, set in the ground and braced. Over the post may be placed a whitewashed tripod, if the station is to be seen at a long distance.

In measuring angles, the instrument is mounted on a trivet placed on the post.

A base-line is selected, and from it the net-work of triangles is developed to include the whole area, and this triangulation is verified by closing on a second measured line.

Base-lines are measured with a chain 20^{m} long, made of links $0^{m}.5$ long.

The links are made of steel wire $0^{m}.005$ diameter, and are connected in the usual way by rings.

When the chain is used for measuring a base-line, its length is determined by comparison with a standard, laid off with a steel bar $1^{m} \times 0^{m}.008 \times 0^{m}.008$, before and after measuring the base.

Two or more measurements are made of each base, and the following degree of accuracy has been attained. In 15 cases examined, the mean discrepancy in chaining base lines was 1 in 17485; the greatest discrepancy, 1 in 5729; the least discrepancy, 1 in 45104.

For the triangulation, an alt-azimuth instrument reading to 10″ or 20″ is used.

When a station is occupied, two or more pointings are made to each station visible from the one occupied, and important angles are determined by repetition.

The following degree of accuracy is attained in closing triangles:

In 26 cases examined, the mean error in closing triangles was 14″; 9 of the above gave a mean error +8″; 17 of the above gave a mean error —7″; the maximum error was —42″.

In carrying the triangulation from one base to another, the following degree of accuracy was obtained:

At Niagara River, from first to second base, (Towar,) 24 triangles; discrepancy in connection, 1 in 2675.

At Buffalo, N. Y., from first to second base, (Terry,) 18 triangles; discrepancy, 1 in 5421.

At East Porter, N. Y., from first to second base, (Eisenmann,) 22 triangles; discrepancy, 1 in 5040.

When the country is obstructed by woods or otherwise, so as to make a triangulation impossible, a line is chained along the shore, or along a road parallel to the shore.

Azimuth is determined by observation on Polaris at elongation on at least two nights.

The following degree of accuracy in this work has obtained:

In 17 cases examined, the mean discrepancy resulting from two nights' observation was 20″. The greatest discrepancy was 1′ 10″.

A comparison of azimuth is made when the work of two parties is joined.

After correction for convergence of meridians, the resulting difference is due to error in observation for azimuth, and to error in carrying the azimuth.

In 26 cases examined, the mean of errors in the connection of azimuths of two parties was 1′ 23″. The largest error was 4′ 42″.

For topography, the stadia is used to delineate the ground covered by the triangulation.

In filling in the details, all roads, streams, buildings, fences, cultivation, and woods are indicated, and contours are determined for every 10 or 20 feet of elevation.

In the instruments used with the stadia-rod, the horizontal wires for stadia-measurements are fixed, and each rod is divided and marked for the instrument with which it is to be used.

The wires are frequently tested, to determine if any change takes place, by reading the rods on a chained line.

Four men are required for a topographical party: One assistant in charge of instrument; one man to carry instrument, record, and do such general work as may be required; two men with stadia-rods.

The work is conducted as follows:

The theodolite is set up over a triangulation-station, pointed and set on a line whose azimuth is known, or assumed for the time in case true azimuth has not been determined by observation, so that the horizontal limb shall give, by reading, the azimuth of the line.

Readings are then taken to prominent points within range (400^m) that are to be located; the distances are at the same time read from the stadia-rods, which are carried from point to point by the stadia-men, as directed by the assistant in charge.

The vertical angles and distances read from the stadia are arguments with which, from a table, horizontal distances and elevations are determined.

The angles and distances are recorded in the note-book, and the work is plotted to the scale of $\frac{1}{10000}$ on a protractor sheet 21″ × 16″ fastened to a light drawing-board; further details are sketched in.

The instrument is next moved to a second point, previously located by stadia from the first point set up, and pointed to the first station on the back azimuth of the line.

The distance back to the first station is read and recorded for a check, and points located from the first station may also be located from the second station.

The prominent points in range are next located as before, and readings are taken to triangulation-stations in sight in order to check the azimuth when the same points are reached with the stadia-work.

In this way the work is continued and closed on a triangulation-point so that the length of the meandered stadia-line is checked by the triangulation.

By computing co-ordinates for the stadia-work for 1875, the average amount of discrepancy in 141 lines, varying in length from 965^m to $6,486^m$, mean $2,450^m$, when compared with lines determined by triangulation or by chaining, was found to be 1 in 649.

The greatest discrepancy or error amounted to 1 in 189 in a line $2,879^m$ long.

The error ought in no case to exceed 1 in 300.

INSHORE HYDROGRAPHY.

Sounding-stations are established along the shore at intervals of from 100 to 500 meters, and a line of buoys 500 to 1,000 metres apart is placed at the outer limit of the space to be sounded, generally in about 4 fathoms of water.

When the distance from the shore to the outer limit of sounding exceeds 1 mile, a second line of buoys is placed midway between the shore and the outer limit.

The sounding-stations are located from the principal stations in running the shore-line.

The buoys are located from the principal shore-line stations by intersection from three points.

This serves as a check on the shore-line and topography; and on an obstructed,

broken, irregular shore, the buoys may form a part of the system of tertiary triangulation, care being taken to check the work by closing on a measured line.

For sounding, a 6-oared cutter, 1 assistant to record, 1 helmsman, 1 leadsman, and 6 oarsmen are employed.

The lead-line is compared with the standard measure every day when in use.

Lines of soundings taken on time are run from the sounding-stations on shore to the buoys so as to cover the area to be sounded out.

During the seasons of 1874 and 1875, the method in most general use was that of running lines of soundings to and from the sounding-stations on shore.

The direction of the lines of soundings was determined by an assistant on shore with a theodolite, and the outer end of each line was fixed by its intersection with the line of buoys.

In sounding, the boat starts from a sounding-station, which is occupied by an assistant with a theodolite, who directs the helmsman in the boat by waving a flag to the right or left, so that the line is run by the boat on an azimuth determined for the lines of soundings generally so as to make the lines perpendicular to the shore. The line is continued in this way till it intersects the line of buoys. The assistant on shore now moves to the next sounding-station, and the boat moves in the same direction on the line of buoys, and again directed by the flag, and a range selected by the helmsman or established by the assistant on shore, runs another line of soundings back to the station on shore now occupied by the assistant.

In running to and from shore, the distance from the sounding-station at the inner end of each line is estimated and recorded.

The soundings are taken on time at intervals of 15^s, 30^s, or 1^m, depending on the depth.

The soundings near shore or in shoal water being most important are taken at every 15^s in running out and in with the boat.

The average speed of the cutter in sounding for a whole day is 70^m per minute.

The number of soundings taken in a space $1,000^m$ square, near shore, in ten cases examined, varied from 66 to 322.

With sounding-stations 200^m apart, and soundings every 15^s, we should have 285 soundings for a space 1,000 metres square, or one sounding for a space 59 metres square.

OFFSHORE HYDROGRAPHY.

Offshore soundings are lines of soundings run by a steamer perpendicular to the general direction of the coast, and about 1 mile apart, commencing within the hydrography done by the shore-parties and extending out 10 miles from land.

Observers with theodolites are placed on shore at two stations about 6 miles apart, readings are taken to two or more prominent stations, and these readings are repeated often enough to detect any movement in the lower limb of the instrument.

The steamer at starting whistles, drops the balloon, and a sounding is taken at the same time, and in running out and in, the balloon is dropped and a sounding is taken every 10 minutes.

At the instant the balloon drops, the observers on shore take readings to the steamer and note the time.

On the steamer, the time of dropping the balloon is noted, and a sextant-angle is read (if possible) for two points located on shore by the triangulation.

The watches used by the observers on shore are compared with the watch used on the steamer before and after the day's work.

In water less than 20 fathoms deep, soundings are taken every 5 minutes.

The lead-line is compared with a standard measure every day when in use.

The notes are plotted every evening, to make sure that the soundings are properly distributed.

Lines of soundings are also run entirely across the lakes, 15 miles apart.

The steamer in this case is located from the shore, when soundings are taken, as long as it remains in sight.

Permanent bench-marks are established, and water-gauges are kept, to which all soundings can be reduced.

OFFICE-WORK.

In the office, topography and inshore hydrography are plotted on a scale of $\frac{1}{10000}$.

The triangulation and co-ordinates of triangulation stations and points located with the chain are computed.

The sheet on which the work is to be plotted is divided by fine lines into squares of 1000^m on a side.

The principal stations are plotted by their co-ordinates, and checked by the lengths of the sides of triangles.

The work plotted on field-sheets is then adjusted to the projection of the principal stations. Buoys are plotted by intersection of these lines.

The soundings are corrected for error of lead-line, are reduced to a plane of reference, and plotted by interpolation between sounding-stations and buoys.

Offshore hydrography is plotted on a scale of $\frac{1}{60000}$.

All note-books and computations are paged, indexed, and preserved for reference.

Notes are made on detail-sheets for reference to the corresponding field-sheets and note-books.

A final check on this work results from the distance between two consecutive secondary stations determined from the primary triangulation.

H. M. ADAMS,
Captain of Engineers.

APRIL 27, 1876.

APPENDIX B.—TELEGRAPHIC LONGITUDE.

REPORT OF LIEUTENANT D. W. LOCKWOOD, CORPS OF ENGINEERS.

OFFICE OF UNITED STATES LAKE SURVEY,
Detroit, Mich., June 26, 1876.

MAJOR: I have to submit the following report of work done under my charge during the fiscal year ending June 30, 1876.

By your letter of instructions dated Office United States Lake Survey, Detroit, Mich., April 10, 1875, I was put in charge of longitude-work for the season, and directed, in connection with Lieutenants Maguire and Bailey (field-observers) to determine the difference of longitude between the Detroit observatory and certain specified places in the interior of this State. Before commencing work, Lieutenant Maguire was relieved from duty on the Lake Survey, and Lieutenant Price took his place as field-observer. In August, Assistant Engineer A. R. Flint was sent (by your orders) to occupy the stations at Tonawanda and Mannsville, N. Y., and the difference of longitude between each of those stations and Detroit was determined.

The season's work of observing began May 10 and ended December 27, during which time thirteen stations were occupied.

The instruments used at Detroit were the sidereal clock, Bond & Son, No. 256, with break-circuit attachment; Würdemann astronomical transit, No. 1, focal length 31 inches, object-glass 2½ inches diameter, magnifying power of eye-piece 100; and Bond & Sons' chronograph, No. 216.

During the first part of the season, both Lieutenants Price and Bailey were furnished with break-circuit sidereal chronometers for sending signals to Detroit, and mean solar chronometers for receiving signals from Detroit by coincidences. After the station at Hastings had been occupied by Lieutenant Bailey, his break-circuit chronometer was replaced by one without that attachment, necessitating a change in the manner of sending signals to Detroit from that used by him up to that time.

The following is the programme adopted at the beginning of the season for time-determinations and exchange of signals. The star-places were those given by the American Ephemeris and German Catalogue of 529 stars for 1875.

TIME-DETERMINATIONS.

Level-readings.
A circumpolar star, (reversal on.)
Level-readings.
Five well-determined time-stars.
Level-readings.
Reversal.
Level-readings.
Five well-determined time-stars.
Level-readings.
A circumpolar star, (reversal on.)
Level-readings.

Then followed correspondence and telegraphic time-signals, after which a series of star-observations, following the same programme as given above.

TELEGRAPHIC SIGNALS.

1st. The field-observer will switch his sidereal chronometer into his local line so as to break circuit on the main line for $1^m\ 20^s$. This connection will be made 10 seconds before the zero second, and will be broken 10 seconds after the second zero second. The times of switching in and out will be recorded by the field-observer, and the chronometer-breaks registered on the Detroit chronograph along with the clock-beats.

2d. The Detroit clock will be switched in in the same manner as described for the chronometer for 7 minutes. The field-observer will note the mean solar chronometer time of coincidences of its beats with the armature breaks.

3d. The Detroit observer will then send arbitrary signals for two minutes, making the breaks approximately at 0^s, 15^s, 30^s, 45^s. These signals will be recorded on the Detroit chronograph and time of receival noted by the field-observer with his sidereal chronometer.

4th. Same as 1st.

5th. Same as 2d.

After the break-circuit chronometer was taken from Lieutenant Bailey, 1st and 4th of the above programme were changed as follows: "The field-observer will for 2 minutes send hand-signals coincident with his sidereal-chronometer ticks every second for 15 seconds—then omit for 15 seconds, then send, and so on."

Assistant Engineer A. R. Flint used a break-circuit sidereal chronometer and chronograph. The exchange of signals with him consisted in switching in 1° the clock for $2^m\ 20^s$, this time including 3 zero seconds of the clock; then the same with the sidereal chronometer.

These signals were then repeated.

At each station in the State, two nights were considered sufficient, where the results agreed closely, $0^s.2$ being the range allowed, and three nights where the range exceeded that given above. At Tonawanda and Mannsville, four complete nights were required, these being primary stations.

Before going into the field, and upon returning therefrom, time-observations to determine the relative personal equation between each field-observer and myself were taken. With Lieutenants Price and Bailey three nights were required, and with Assistant Engineer Flint two on each occasion.

The same programme for time-determinations and exchange of signals was followed as has already been given, except that the signals with Lieutenant Price before going into the field consisted only of those from his chronometer, no coincidences being taken.—After Lieutenant Price returned, the regular programme was followed, and the results show a mean difference of $0^s.01$ between signals in different directions.

The different nights' observations (time) with Assistant Engineer Flint were reduced by the method of least squares, the unknown quantities being the correction to the assumed clock-error,—the rate per hour, and azimuth. The collimation was determined from reversals on slow stars.—The remainder of the time-work for the season was reduced by the method of high and low stars, collimation being determined as indicated above, and deviation by the mean of the results obtained by combining each slow star with two time-stars, where the range did not exceed $0^s.3$. In case it did, a different value for deviation was used for different parts of the programme, in each instance being that derived from the nearest slow star. The same course was followed with regard to the collimation when the night's range exceeded $0^s.11$.

The rate was determined from the difference between the means of the individual results for error of clock before and after signals.

In the reduction by least squares, the equations of condition were weighted according to the number of wires observed and the probable error of a transit over a single wire. The probable error for time-stars over a single wire was taken at $0^s.07$, and the weight unity given to a mean of seven wires.

The formula by which the weight for slow stars was determined is as follows:

$$p = \frac{(.07)^2}{(r^2)} \cdot p'$$

in which $0^s.07$ = probable error for transit of a time-star over a single wire, r = same for slow star determined from all the observations taken on it, and p' = the weight due to the number of wires over which the slow star was observed. The value of p' was found from the formula

$$p' = \frac{\varepsilon_1^2 + \frac{\varepsilon^2}{N}}{\varepsilon_1^2 + \frac{\varepsilon^2}{n}}$$

in which ε_1 = probable culmination error, &c., ε = probable error of a transit of a time-star over a single wire, N = number of wires to which the weight unity is given, and n = the number of wires over which the slow star was observed.

Making ε_1 equal to $0^s.056$, (Appendix 12, Coast Survey Report, 1872,) ε equal to $0^s.07$, and N equal to 7, the above formula becomes—

$$p' = \frac{(.056)^2 + \frac{(.07)^2}{7}}{(.056)^2 + \frac{(.07)^2}{n}}$$

and p, (the weight with which the equation of condition for the slow star is to be effected,)

$$=\frac{(.07)^2}{(r^2)}\cdot\frac{(.056)^2+\frac{(.07)^2}{7}}{(.056)^2+\frac{(.07)}{n}}$$

As the latest determination of the values of the equatorial-wire intervals was made in 1865, new values were deduced from the observations on slow stars made during the season. The value of one division of the striding-level was determined by Assistant Engineer Flint to be $0''.918$, or, in time, $0^s.0612$—.

The value of the pivot-correction was determined by myself to be 0.65 of 1 division of the striding-level, or $0''.597$—. These values were used in making the time-reductions.

All time and other computations have been duplicated or checked.

Lieutenant Price occupied the stations at Charlotte, Marshall, Kalamazoo, Paw-Paw, and Stanton; Lieutenant Bailey those at Howell, Lansing, Hastings, Jackson, Allegan, and Newaygo.

NOTATION.

$\Delta T'$ = individual result from each star.
ΔT = assumed clock-error at epoch.
δt = correction of ΔT.
a = assumed deviation.
δa = Correction of a.
ρ = rate per hour, − when gaining, + when losing.

Individual and mean results for correction of clock at Detroit.

Star.	May 10. Δt′ of clock at 15h. 00m. sidereal time.	May 12. Δt′ of clock at 15h. 00m. sidereal time.	Star.	May 15. Δt′ of clock at 15h. 00m. sidereal time.
	m. s.	m. s.		m. s.
2 Canis Venaticorum	− 1 6.81	− 1 7.31	43 Comæ	− 1 7.63
η Virginis	7.10	7.20	20 Canis Venaticorum	7.54
6 Canis Venaticorum	6.93	7.34	α Virginis	7.65
20 Comæ	7.08	7.16	ζ Virginis	7.67
24 Comæ	7.27	7.25	τ Bootis	7.64
γ Virginis	7.11	7.29	η Bootis	7.60
δ Virginis	7.15	7.49	τ Virginis	7.62
ε Virginis	7.26	7.44	δ Bootis	7.50
θ Virginis	6.70	7.35	ι Virginis	7.85
43 Comæ	7.13	....	φ Virginis	7.62
ζ Virginis	6.94	7.26	ρ Bootis	7.67
τ Bootis	7.06	7.33	π Bootis, pr	7.75
η Bootis	7.00	7.40	γ Herculis	7.51
τ Virginis	6.99	7.47	ω Herculis	7.56
β Scorpii	7.00	7.56	λ Ophiuchi	7.78
δ Ophiuchi	6.92	7.42	ζ Ophiuchi	7.63
ε Ophiuchi	6.99	7.48	ζ Herculis	7.38
γ Herculis	7.23	7.47	49 Herculis	7.80
ω Herculis	7.13	7.50	ε Herculis	7.60
β Herculis	6.98	7.31	60 Herculis	7.76
ζ Ophiuchi	6.89	7.18	Gr. 2415	7.74
ζ Herculis	7.05	6.97	α Herculis	7.70
η Herculis	7.00	7.12	α Ophiuchi	7.61
49 Herculis	7.09	7.28	β Ophiuchi	7.68
Mean	− 1 07.034	− 1 07.330	Mean	− 1 7.645
Rate per hour	− 0.079	0.000	Rate per hour	− 0.014

Individual and mean results for correction of clock at Detroit—Cotinued.

Star.	June 3. Δt′ of clock at 15h. sidereal time.	Star.	June 18. Δt′ of clock at 17h. 30m. sidereal time.	June 19. Δt′ of clock at 17h. 30m. sidereal time.
	m. s.		m. s.	m. s.
43 Comæ	— 1 10. 23	μ Bootis	— 1 11. 00	— 1 11. 25
20 Canis Venaticorum	10. 10	β Coronæ	11. 22	11. 06
ζ Virginis	10. 23	ν Bootis, pr	11. 18	11. 23
τ Bootis	10. 14	ζ Coronæ	11. 05	11. 00
η Bootis	10. 07	γ Coronæ	11. 06	11. 11
τ Virginis	9. 94	ε Serpentis	11. 19	10. 97
δ Bootis	9. 96	γ Serpentis	11. 26	11. 01
ι Virginis	9. 94	β Scorpii	11. 21	10. 88
φ Virginis	10. 15	δ Ophiuchi	10. 93	10. 96
ρ Bootis	9. 99	ε Ophiuchi	10. 86	10. 99
π Bootis	10. 19	γ Herculis	11. 10	11. 07
γ Herculis	10. 02	ζ Ophiuchi	11. 03	10. 92
σ Herculis	10. 13	ζ Herculis	10. 95	11. 04
λ Ophiuchi	9. 88	η Herculis	11. 08	11. 03
ζ Ophiuchi	9. 71	49 Herculis	11. 16	11. 08
ζ Herculis	9. 94	1 Aquilæ	11. 01	10. 83
49 Herculis	10. 06	110 Herculis	10. 75	10. 81
ε Herculis	10. 36	β Lyræ	11. 04	11. 15
60 Herculis	10. 14	θ Serpentis, pr	11. 06	11. 14
Gr. 2415	10. 31	ε Aquilæ	10. 98	11. 02
α Herculis	10. 25	ι Lyræ	11. 15	11. 02
α Ophiuchi	10. 06	ω Aquilæ	11. 12	11. 15
β Ophiuchi	10. 14	δ Aquilæ	11. 18	11. 11
		β Cygni	11. 17	11. 07
		κ Aquilæ	11. 31	11. 09
Mean	— 1 10. 084	Mean	— 1 11. 082	— 1 11. 040
Rate per hour	— 0. 006	Rate per hour	— 0. 037	— 0. 029

Individual and mean results for correction of clock at Detroit.

Star.	July 13. Δt′ of clock at 18h. 40m. sidereal time.	July 19. Δt′ of clock at 18h. 40m. sidereal time.	July 20. Δt′ of clock at sidereal time.
	m. s.	m. s.	m. s.
ζ Ophiuchi	— 1 16. 31	— 1 17. 17	— 1 17. 22
ζ Herculis	16. 17	17. 20	17. 27
η Herculis	16. 18	17. 27	17. 28
49 Herculis	16. 44	17. 39	17. 46
κ Ophiuchi	16. 33	17. 33	17. 30
ε Herculis	16. 27	17. 29	17. 19
α^1 Herculis	16. 36	17. 37	17. 44
π Herculis	16. 19	17. 22	17. 39
α Ophiuchi	16. 25	17. 47	17. 49
β Ophiuchi	16. 23	17. 49	17. 44
γ Ophiuchi	16. 30	17. 54	17. 55
θ Herculis	16. 26	17. 26	17. 50
67 Ophiuchi	16. 17	17. 40	17. 50
72 Ophiuchi	16. 22	17. 41	....
α^2 Capricorni	16. 35	17. 53	17. 54
γ Cygni	16. 10	17. 17	17. 44
π Capricorni	16. 16	17. 42	17. 43
ε Delphini	16. 41	17. 44	17. 37
α Delphini	16. 43	17. 24	17. 44
γ^2 Delphini	16. 45	17. 36	17. 28
μ Aquarii	16. 33	17. 40	17. 34
ν Cygni	16. 08	17. 19	17. 35
61^1 Cygni	16. 06	17. 29	17. 48
ζ Cygni	....	17. 37	17. 25
Mean	— 1 16. 264	— 1 17. 343	— 1 17. 389
Rate per hour	— 0. 0096	— 0. 0043	— 0. 022

Individual and mean results for correction of clock at Detroit.

Star.	July 24.	July 26.	July 30.	August 7.	August 12.	August 13.	August 24.
	$\Delta t'$ of clock at 20*h*. 30*m*. sid. time.	$\Delta t'$ of clock at 20*h*. 30*m*. sid. time.	$\Delta t'$ of clock at 20*h*. 30*m*. clock time.	$\Delta t'$ of clock at 20*h*. 30*m*. clock time.	$\Delta t'$ of clock at 20*h*. 30*m*. sid. time.	$\Delta t'$ of clock at 20*h*. 30*m*. sid. time.	$\Delta t'$ of clock at 20*h*. 30*m*. sid. time.
	m. *s.*	*m.* *s.*	*m.* *s.*	*m.* *s.*	*m.* *s.*	*m.* *s.*	*m.* *s.*
1 Aquilæ	— 1 17.33	....	— 1 17.47	— 1 17.99	— 1 18.32	— 1 18.51	— 1 19.82
α Lyræ	17.26	— 1 17.63	17.26	17.84	18.19	18.52	19.56
110 Herculis	17.15	17.45	17.16	17.83	....	18.37	19.56
β Lyræ	17.33	17.58	17.28	18.03	18.24	18.38	19.66
θ^1 Serpentis	17.30	....	17.32	18.05	18.30	18.55	19.72
ε Aquilæ	17.26	17.57	17.28	17.97	18.20	18.45	19.69
ζ Aquilæ	17.46	17.36	17.52	17.72	18.36	18.37	19.96
ι Lyræ	17.30	....	17.44	17.73	....	18.43	19.82
ω Aquilæ	17.42	17.39	17.47	....	....	18.46	19.87
δ Aquilæ	17.42	17.37	....	17.71	....	18.32	19.85
β Cygni	17.36	17.26	17.29	17.72	....	18.38	19.73
κ Aquilæ	17.36	17.33	17.42	17.72	....	18.33	19.93
ξ Aquarii	....	17.36	17.13	....	18.15	18.32	19.87
ε Pegasi	17.13	....	17.22	....	18.17	18.22	19.83
μ Capricorni	17.20	....	17.21	....	18.22	18.29	19.85
20 Pegasi	17.24	17.41	17.28	17.73	18.17	18.42	19.65
α Aquarii	17.19	17.43	17.24	17.85	18.14	18.31	19.92
θ Pegasi	17.29	17.39	17.22	17.81	18.25	....	19.83
θ Aquarii	17.28	17.38	17.27	17.87	18.19	....	19.90
γ Aquarii	17.47	17.61	17.52	17.83	18.44	....	19.75
π Aquarii	17.39	17.49	17.45	17.88	18.29	18.55	19.63
η Aquarii	17.45	17.42	17.50	17.82	18.29	18.53	19.62
ζ Pegasi	17.46	17.45	17.69	17.93	18.37	18.52	19.67
λ Pegasi	17.44	17.45	....	17.79	18.30	18.50	19.71
μ Pegasi	17.40	17.43	17.49	17.73	18.35	18.47	19.74
λ Aquarii	....	....	....	17.87	18.45	18.53	19.72
Mean	— 1 17.329	— 1 17.438	— 1 17.3535	— 1 17.837	— 1 18.2695	— 1 18.423	— 1 19.764
Rate per hour	+ 0.034	+ 0.0095	— 0.005	+ 0.0365	— 0.0005	— 0.0294	+ 0.0033

Individual and mean results for correction of clock at Detroit.

Star.	August 28. $\Delta t'$ of clock at 22*h.* 00*m.* sid. time.
	m. *s.*
α^2 Capricorni	— 1 20.33
γ Cygni	20.24
π Capricorni	20.29
ε Delphini	20.35
α Delphini	20.38
δ Delphini	20.35
γ^2 Delphini	20.55
ν Cygni	20.38
61^1 Cygni	20.13
ζ Cygni	20.39
τ Pegasi	20.36
υ Pegasi	20.41
θ Piscium	20.54
72 Pegasi	20.50
ι Andromedæ	20.31
ι Piscium	20.33
ψ Pegasi	20.30
ω Piscium	20.30
α Andromedæ	20.23
γ Pegasi	20.25
ι Ceti	20.25
12 Ceti	20.28
Mean	— 1 20.339
Rate per hour	— 0.0192

Individual and mean results for correction of clock at Detroit.

Star.	August 30.	August 31.	September 23.	September 24.
	$\Delta t'$ of clock at 22*h.* 00*m.* clock-time.	$\Delta t'$ of clock at 22*h.* 00*m.* clock-time.	$\Delta t'$ of clock at 22*h.* 00*m.* clock-time.	$\Delta t'$ of clock at 22*h.* 00*m.* clock-time.
	m. s.	*m. s.*	*m. s.*	*m. s.*
λ Ursæ Minoris	−1 20.00	−1 19.87	−1 21.30	−1 18.40
θ Aquilæ	20.51	20.75	20.87	20.54
α_2 Capricorni	20.58	20.68	....	....
24 Vulpeculæ	....	....	20.80	20.47
γ Cygni	20.50	20.68	20.75	20.53
π Capricorni	20.47	20.76	20.86	20.63
ε Delphini	20.62	20.86	20.81	20.57
α Delphini	20.61	20.84	20.73	20.50
δ Delphini	20.77	20.88	20.79	20.50
γ^2 Delphini	20.88	20.96	....	....
ε Aquarii	....	....	20.69	20.50
ν Cygni	20.61	20.61	20.69	20.35
61^1 Cygni	20.67	20.78	20.67	20.47
ζ Cygni	20.69	20.80	20.76	20.36
1 Draconis, L. C	20.47	20.71	20.75	20.71
Carr. 3525	20.66	....	....	....
τ Pegasi	20.68	20.75	....	....
υ Pegasi	20.67	20.71	....	20.52
θ Piscium	20.68	20.76	....	20.55
72 Pegasi	20.82	20.85	....	20.67
ι Andromedæ	20.51	20.78	....	20.44
ι Piscium	20.58	20.60	....	20.57
ψ Pegasi	20.63	20.86	....	20.46
ω Piscium	20.62	20.77	....	20.48
α Andromedæ	20.54	20.80	....	20.43
γ Pegasi	20.54	20.78	20.78	20.44
ι Ceti	20.58	20.88	20.77	20.51
12 Ceti	20.62	....	20.89	20.53
π Andromedæ	21.05	....	20.86	....
υ Andromedæ	....	....	20.70	....
32 Camelopardalis, L. C	....	20.68	20.01	20.07
β Andromedæ	....	....	20.65	....
τ Piscium	....	....	20.67	....
γ Piscium	....	....	20.72	....
θ^1 Ceti	....	....	20.82	....
η Piscium	....	....	20.90	....
Adopted value	−1 2[illegible] [illegible]30	−1 20.7776	−1 20.769	−1 20.4862
Rate per hour	− 0 [illegible]255	− 0.002	+ 0.0243	− 0.004
Assumed value of Δt at 22*h.* clock-time	−1 20.[illegible]0	−1 20.70	−1 20.50	−1 20.30
Assumed value of *a*	− 0.[illegible]	− 0.68	+ 1.6	+ 1.5

Normal equations August 30.

δt	$\delta a'$	r	n
+ 23.20	+ 10.99	+ 5.84	+ 1.0[illegible] = 0
+ 10.99	+ 16.81	+ 3.25	+ 1.0[illegible] = 0
+ 5.84	+ 3.25	+ 62.20	+ 1.1[illegible] = 0
− .0296 −	.0403 −	.0255	

Normal equations August 31.

δt	$\delta a'$	r	n
+ 22.16	+ 10.53	+ 3.40	+ 1.75 = 0
+ 10.53	+ 14.84	+ 1.76	+ .89 = 0
+ 3.40	+ 1.76	+ 56.42	+ .35 = 0
− .0776 −	.006 −	.002	

Normal equations September 23.

δt	$\delta a'$	r	n
+ 21.16	+ 10.02	+ 12.64	+ 5.18 = 0
+ 10.02	+ 14.47	+ 5.92	+ 2.23 = 0
+ 12.64	+ 5.92	+ 103.99	+ .92 = 0
− .269 +	.0234 +	.0243	

Normal equations September 24.

δt	$\delta a'$	r	n
+ 22.16	+ 10.72	+ 4.43	+ 3.09 = 0
+ 10.72	+ 14.72	+ 3.48	+ .54 = 0
+ 4.43	+ 3.48	+ 60.61	+ .72 = 0
− .1862 +	.111 −	.004	

Individual and mean results for correction of clock at Detroit.

Star.	October 2.	October 8.	October 13.	October 18.	October 20.
	$\Delta t'$ of clock at $0h.\ 00m.$ clock-time.	$\Delta t'$ of clock at $0h.\ 00m.$ clock-time.	$\Delta t'$ of clock at $0h.\ 00m.$ clock time.	$\Delta t'$ of clock at $0h.$ $00m.$ sidereal time.	$\Delta t'$ of clock at $0h.\ 00m.$ sidereal time.
	m. s.	*m. s.*	*m. s.*	*m. s.*	*m. s.*
1 Draconis, L. C	− 1 19. 74	− 1 18. 00	− 1 16. 44	....	....
ξ Aquarii	19. 76	18. 90	16. 89	− 1 15. 15	− 1 14. 18
ε Pegasi	19. 62	18. 73	16. 88	15. 09	13. 84
μ Capricorni	19. 67	18. 87	16. 97	15. 10	13. 93
20 Pegasi	19. 69	18. 88	16. 91	15. 01	....
α Aquarii	19. 76	18. 81	16. 96	15. 11	14. 00
θ Pegasi	19. 68	18. 87	16. 96	15. 07	13. 98
θ Aquarii	19. 72	18. 90	16. 95	15. 12	14. 01
γ Aquarii	19. 68	18. 61	16. 90	15. 00	14. 03
π Aquarii	19. 70	18. 52	16. 90	14. 94	13. 95
η Aquarii	19. 71	18. 68	16. 94	15. 00	14. 01
ξ Pegasi	19. 76	18. 62	16. 97	15. 04	14. 01
λ Pegasi	19. 84	18. 75	16. 94	14. 86	13. 91
μ Pegasi	19. 78	18. 61	16. 95	15. 06	13. 92
Carr. 3525	21. 02	18. 59	17. 53	....	....
γ Piscium	....	....	....	15. 12	....
τ Pegasi	....	....	....	15. 04	....
υ Pegasi	....	....	....	15. 02	....
α Ursæ Minoris	13. 99	16. 61	13. 60	....	....
β Arietis	19. 69	18. 78	16. 86	14. 99	13. 90
γ Andromedæ	19. 82	18. 50	16. 76	15. 00	13. 95
α Arietis	19. 63	18. 65	16. 85	14. 86	13. 88
ξ¹ Ceti	19. 71	18. 68	16. 88	15. 00	13. 98
γ Trianguli	19. 65	18. 70	16. 84	14. 99	13. 89
θ Arietis	....	....	....	....	13. 99
ξ² Ceti	19. 75	18. 90	17. 03	15. 13	14. 15
γ Aretis	19. 65	18. 84	16. 86	15. 14	14. 04
γ Ceti	19. 75	18. 93	16. 96	15. 06	14. 00
41 Arietis	19. 79	....	....	15. 05	13. 94
η Eridani	19. 68	....	17. 06	15. 13	14. 06
α Ceti	19. 70	....	17. 01	15. 13	14. 00
Carr. 491	21. 30	....	17. 24	....	....
Adopted value	− 1 19. 718	− 1 18. 738	− 1 16. 920	Mean = − 1 15.045	− 1 13. 981
Rate per hour	+ 0. 0097	+ 0. 062	+ 0. 036	0.0037	+ 0. 0176
Assumed value of Δt at $0h.$ clock-time	− 1 19. 70	− 1 18. 7	− 1 16. 80		
Assumed value of a.	0. 00	0. 00	0. 00		

Normal equations October 2.

δt	δa	r	n
+ 24. 21	+ 13. 00	+ 2. 35	+ . 01 = 0
+ 13. 00	+ 20. 49	− 5. 74	− . 34 = 0
+ 2. 35	− 5. 74	+ 109. 98	− . 92 = 0
− . 0180	+ . 031	+ . 0097	

Normal equations October 8.

δt	δa	r	n
+ 21. 19	+ 11. 54	− 6. 28	− 1. 73 = 0
+ 11. 54	+ 16. 04	− 9. 71	− 3. 02 = 0
− 6. 28	− 9. 71	+ 85. 32	− 3. 08 = 0
− . 0378	+ . 253	+ . 062	

Normal equations October 13.

δt	δa	r	n
+ 23. 21	+ 12. 69	− . 40	+ . 64 = 0
+ 12. 69	+ 20. 37	− 6. 58	− 1. 69 = 0
− . 40	− 6. 58	+ 102. 65	− 2. 63 = 0
− . 1199	+ . 1677	+ . 0360	

Individual and mean results for correction of clock at Detroit.

Star.	November 4. Δt' of clock at 1h. 32m. 06s. clock-time.	November 10. Δt' of clock at 1h. sidereal time.	November 5. Δt' of clock at 2h. clock-time.
	m. s.	m. s.	m. s.
τ Pegasi	—1 9.74		—1 09.17
υ Pegasi	9.80		9.15
70 Pegasi	9.74		9.18
72 Pegasi	9.88		9.31
ι Piscium	9.80		9.12
ψ Pegasi	9.87	—1 6.69	9.15
ω Piscium	9.79	6.74	9.07
α Andromedæ	9.73	6.68	8.88
γ Pegasi	9.67	6.68	9.00
ι Ceti	9.79	6.93	9.08
12 Ceti	9.81	6.90	9.02
π Andromedæ		6.75	
ε Andromedæ	9.69	6.72	8.95
ζ Andromedæ		6.70	
γ Andromedæ		6.71	
α Arietis		6.72	
β Trianguli		6.75	
ξ¹ Ceti		6.84	
γ Trianguli		6.70	
θ Arietis		6.78	
ξ² Ceti		6.81	
ι Arietis		6.68	
γ Ceti		6.77	
μ Ceti		6.74	
41 Arietis	9.69	6.78	9.08
η Eridani	9.83	6.79	9.06
α Ceti	9.73		9.11
β Persei	9.64		9.11
δ Arietis	9.65		
ζ Arietis	9.60		
ο Tauri	9.84		
ξ Tauri	9.95		
f Tauri	9.76		
ε Eradani	9.97		
ο Persei	9.72		
η Tauri	9.82		
Mean	—1 9.771	—1 6.755	—1 9.090
Rate per hour	+ 0.0027	+ 0.030	+ 0.0375

Individual and mean results for correction of clock at Detroit.

Star.	November 6.	November 8.	November 11.	November 12.
	Δt′ of clock at 1*h*. 30*m*. clock-time.	Δt′ of clock at 1*h*. 30*m*. clock-time.	Δt′ of clock at 1*h*. 30*m*. clock-time.	Δt′ of clock at 1*h*. 30*m*. clock-time.
	m. *s*.	*m*. *s*.	*m*. *s*.	*m*. *s*.
Carr. 3525	−1 8.93	....	−1 5.56	−1 5.72
γ Piscium	....	....	6.39	6.10
τ Pegasi	8.65	....	6.29	5.99
υ Pegasi	....	....	6.31	6.07
κ Piscium	....	....	6.38	6.13
70 Pegasi	8.74	....	6.33	6.05
72 Pegasi	8.88	....	6.40	6.08
ι Piscium	8.65	−1 7.68	6.32	6.08
ψ Pegasi	8.62	7.70	6.30	6.00
ω Piscium	8.65	7.66	6.34	6.19
α Andromedæ	8.71	7.57	6.30	5.95
γ Pegasi	8.65	7.71	6.42	6.10
ι Ceti	8.52	7.81	6.46	6.21
12 Ceti	8.63	....	6.45	6.12
π Andromedæ	....	7.78	6.38	6.10
ε Andromedæ	8.47	7.76	6.27	5.97
ζ Andromedæ	....	....	6.26	5.96
32 Camelopardalis, L. C.	8.47	7.63	6.48	5.52
β Andromedæ	....	7.35	....	....
τ Piscium	....	7.49	....	....
Bradly, 344	8.90	8.36	6.93	6.50
41 Arietis	8.67	7.63	6.32	6.12
η Eridani	8.75	7.76	6.40	6.22
α Ceti	8.59	7.75	6.35	6.13
ρ Persei	....	....	....	5.93
β Persei	....	7.57	6.22	5.95
δ Arietis	8.58	7.61	6.35	6.09
ζ Arietis	8.57	7.66	6.33	....
o Tauri	8.67	7.65	6.27	6.06
ξ Tauri	8.81	7.75	6.54	6.20
f Tauri	8.64	7.56	6.23	5.97
ε Eridani	8.78	7.61	6.44	6.12
o Persei	8.60	7.66	6.34	....
η Tauri	8.68	7.67	6.26	6.08
27 Tauri	....	....	....	6.04
Carr. 580	8.88	7.49	7.07	....
Adopted value	−1 8.661	−1 7.653	−1 6.343	−1 6.071
Rate per hour	— 0.0088	+ .0034	+ .0098	+ .0143
Assumed value of Δt′ at 1*h*. 30*m* clock-time	−1 8.60	−1 7.60	−1 6.30	−1 6.10
Assumed value of *a*	— 5.4	+ 0.7	0.0	0.0

Normal equations November 6.

$$\begin{array}{rrrrl} \delta t & \delta a & r & n & \\ +22.27 & +10.24 & +\ 1.56 & +1.55 & =0 \\ +10.24 & +15.44 & +\ .32 & +\ .89 & =0 \\ +\ 1.56 & +\ .32 & +65.65 & +\ .61 & =0 \end{array}$$

$$-\ .061 -\ .018 -\ .0088$$

Normal equations November 8.

$$\begin{array}{rrrrl} \delta t & \delta a & r & n & \\ +22.22 & +\ 9.37 & +\ 8.82 & +\ .73 & =0 \\ +\ 9.37 & +12.72 & +\ 2.33 & -\ .10 & =0 \\ +\ 8.82 & +\ 2.33 & +54.22 & +\ .18 & =0 \end{array}$$

$$-\ .053 +\ .048 +\ .0034$$

Normal equations November 11.

$$\begin{array}{rrrrl} \delta t & \delta a & r & n & \\ +28.27 & +12.50 & -\ 5.30 & +4.16 & =0 \\ +12.50 & +16.62 & -\ 3.80 & +4.40 & =0 \\ -\ 5.30 & -\ 3.80 & +84.01 & -1.93 & =0 \end{array}$$

$$-\ .043 -\ .230 +\ .0098$$

Normal equations November 12.

$$\begin{array}{rrrrl} \delta t & \delta a & r & n & \\ +28.19 & +12.76 & -\ 5.59 & +1.29 & =0 \\ +12.76 & +14.04 & -\ 1.94 & +1.90 & =0 \\ -\ 5.59 & -\ 1.94 & +83.43 & -1.34 & =0 \end{array}$$

$$+\ .029 -\ .159 +\ .0143$$

Individual and mean results for correction of clock at Detroit.

Star.		December 22. $\Delta t'$ of clock at 3*h*. clock-time.	December 27. $\Delta t'$ of clock at 3*h*. clock-time.
		s.	*s.*
	Polaris	— 50. 79	
ν	Piscium	55. 30	
o	Piscium	55. 15	
	Carr. 2080, L. C		— 55. 71
α	Trianguli	55. 09	
β	Arietis	55. 13	
γ	Andromedæ	55. 12	55. 55
α	Arietis	55. 16	55. 45
β	Trianguli		55. 49
ξ^1	Ceti	55. 12	55. 44
γ	Trianguli	55. 13	55. 46
δ	Arietis	55. 11	55. 46
ξ^2	Ceti	55. 16	55. 55
ν	Arietis	55. 09	55. 49
δ	Ceti	55. 15	55. 49
γ	Ceti		55. 52
μ	Ceti		55. 56
41	Arietis		55. 60
451	Carr	55. 99	55. 82
f	Tauri	55. 12	
ε	Eridani	55. 23	
o	Persei	55. 24	55. 54
17	Tauri		55. 52
η	Tauri	55. 17	55. 47
27	Tauri		55. 47
ζ	Persei	55. 13	55. 40
γ^1	Eridani	55. 25	55. 53
o^1	Eridani	55. 12	55. 58
γ	Tauri	55. 12	55. 50
δ	Tauri	55. 15	55. 44
ε	Tauri	55. 15	55. 51
α	Tauri	55. 17	55. 52
τ	Tauri	55. 12	55. 46
ε	Ursæ Minoris, L. C	54. 74	55. 53
	Adopted value	— 55. 155	— 55. 504
	Rate per hour	+ 0. 0065	— 0. 0014
	Assumed value of ΔT at 3*h*. clock-time	— 55. 00	— 55. 40
	Assumed value of a	0. 00	0. 00

Normal equations December 22.

δt	δa	ρ		
+ 24. 15	+ 11. 00	— 0. 95	+ 0. 64	= 0
+ 11. 00	+ 15. 00	— 2. 46	+ 4. 27	= 0
— 0. 95	— 2. 46	+ 25. 70	— 1. 00	= 0
— . 155	+ . 397	+ . 0065		

Normal equations December 27.

δt	δa	$\delta a'$	ρ		
+ 24. 17	+ 8. 58	+ 1. 92	+ 4. 60	+ 2. 33	= 0
+ 1. 92	+ 0.	+ 2. 14	— 1. 76	— . 48	= 0
+ 8. 58	+ 10. 43	+ 0.	+ 5. 40	— 1. 39	= 0
+ 4. 60	+ 5. 40	— 1. 76	+ 20. 79	+ 1. 33	= 0
— 0. 104	— 0. 046	+ 0. 319	— . 0014		

EXPLANATION OF TABLES.

Lieutenants Price and Bailey.

In observing for relative personal equation, the Detroit observer used the clock and chronograph and the transit mounted on the east pier. The field-observer used a mean solar chronometer for receiving signals by coincidences, and a break-circuit sideral chronometer for observing time and for sending automatic signals to the Detroit observer. These signals were recorded on the chronograph of the Detroit observer. While working in the field, the same instruments were used, and in the same way as for personal equation.

The field-signals to Detroit are arranged in groups, usually four, of twenty single results, and the mean of each taken.

The first column shows the time-piece or station from which signals were sent.

The second column gives the Detroit clock-time of the mean of a group of signals sent from the field, and the clock-time of coincidences observed in the field.

The third column gives the clock-correction for error and rate at the instant of sending or receiving signals.

The fourth column gives the sidereal time of sending or receiving signals, and results from the clock-time, with the correction for error and rate applied.

The fifth column gives the mean solar-chronometer time of coincidences as observed by field-observer.

The sixth column gives field sidereal chronometer time of sending automatic signals to Detroit.

The seventh column gives correction for error and rate of mean solar and sidereal chronometers to instant of comparison.

The eighth column gives local sidereal time of comparison as determined by field-observer.

The ninth column gives individual results for difference of longitude as determined by each coincidence or groups of automatic signals sent to Detroit.

The tenth column gives the mean of all results for each direction.

In the table for relative personal equation with Lieutenant Price, June 3, 18, and 19, the fifth column is omitted, as no coincidences were taken. The fifth, sixth, seventh, eighth, and ninth columns correspond to the sixth, seventh, eighth, ninth, and tenth, as described.

Telegraphic longitude—1875.

PERSONAL EQUATION—LIEUTENANTS LOCKWOOD AND PRICE.

Signals sent from—	Detroit.			Detroit.			Difference.	Mean each night.
	Detroit clock.	Correction.	Sidereal time.	Sidereal chronometer.	Correction.	Sidereal time.		
	h. m. s.	*m. s.*	*h. m. s.*	*h. m. s.*	*s.*	*h. m. s.*	*s.*	*s.*
June 3, sidereal chronometer	15 12 38.910	—1 10.085	15 11 28.825	15 12 00.000	—31.106	15 11 28.894	—0.069	
	15 13 38.910	—1 10.085	15 12 28.825	15 13 00.000	—31.106	15 12 28.894	— .069	—0.069
June 18, sidereal chronometer....................	18 25 41.642	—1 11.115	18 24 30.527	18 25 00.000	—29.562	18 24 30.438	+ .089	
	18 26 41.642	—1 11.116	18 25 30.526	18 26 00.000	—29.562	18 25 30.438	+ .088	+ .088
June 19, sidereal chronometer....................	17 53 42.800	—1 11.051	17 52 31.749	17 53 00.000	—28.311	17 52 31.689	+ .060	
	17 54 42.800	—1 11.051	17 53 31.749	17 54 00.000	—28.311	17 53 31.689	+ .060	+ .060
							Mean......	+ .026

	s.
Mean June 3, 18, and 19...........	+ .026
Mean November 5, 11, and 12	— .030
Mean of all.................	— .002
Difference of time between piers..	— .004
Relative personal equation.......	— .006

Lieutenant Price observes earlier than Lieutenant Lockwood; and, as he occupied stations to the west of Detroit, the above quantity must be added to observed differences of longitude to free the results from relative personal equation.

Telegraphic longitude—1875.

PERSONAL EQUATION—LIEUTENANTS LOCKWOOD AND PRICE.

Signals sent from—	Detroit.			Detroit.				Difference.	Mean each night.
	Detroit clock.	Correction.	Sidereal time.	Mean solar chronometer.	Sidereal chronometer.	Correction.	Sidereal time.		
	h. m. s.	*m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*s.*	*s.*
Nov. 5, chronometer	1 09 31.246	—1 08.122	1 08 22.124	....	1 13 00.000	— 4 37.889	1 08 22.111	+0.013	
	1 10 31.242	—1 09.122	1 09 22.120	....	1 14 00.000	— 4 37.887	1 09 22.113	+0.007	
	1 44 31.307	—1 09.100	1 43 22.207	....	1 48 00.000	— 4 37.824	1 43 22.176	+0.031	
	1 45 31.307	—1 09.100	1 44 22.207	....	1 49 00.000	— 4 37.822	1 44 22.178	+0.029	+0.020
Nov. 5, clock	1 28 11.000	—1 09.110	1 27 01.890	10 24 45.500	....	+15 02 16.393	1 27 01.893	—0.003	
	1 31 11.000	—1 09.109	1 30 01.891	10 27 45.000	....	+15 02 16.891	1 30 01.891	0.000	
	1 52 13.000	—1 09.095	1 51 03.905	10 48 43.500	....	+15 02 20.379	1 51 03.879	+0.027	
	1 55 13.000	—1 09.094	1 54 03.906	10 51 43.000	....	+15 02 20.879	1 54 03.877	+0.029	+0 016
									+0.018
Nov. 11, chronometer	1 38 50.205	—1 06.342	1 37 43.863	....	1 42 00.000	— 4 16.078	1 37 43.922	—0.059	
	1 39 50.204	—1 06.341	1 38 43.863	....	1 43 00.000	— 4 16.077	1 38 43.923	—0.060	
	1 49 50.249	—1 06.340	1 48 43.909	....	1 53 00.000	— 4 16.066	1 48 43.934	—0.025	
	1 50 50.253	—1 06.340	1 49 43.913	....	1 54 00.000	— 4 16.065	1 49 43.935	—0.022	—0.042
Nov. 11, clock	1 45 15.000	—1 06.341	1 44 08.659	10 17 54.500	....	+15 26 14.213	1 44 08.713	—0.054	
	1 48 16.000	—1 06.340	1 47 09.660	10 20 55.000	....	+15 26 14.709	1 47 09.709	—0.049	
	1 54 15.000	—1 06.339	1 53 08.661	10 26 53.000	....	+15 26 15 695	1 53 08.695	—0.034	
	1 57 16.000	—1 06.339	1 56 09.661	10 29 53.500	....	+15 26 16.192	1 56 09.692	—0.031	—0.042
									—0.042
Nov. 12, chronometer	1 47 23.281	—1 06.067	1 46 17.214	....	1 50 30.000	— 4 12.704	1 46 17.296	—0.082	
	2 00 53.300	—1 06.064	1 59 47.236	....	2 04 00.000	— 4 12.690	1 59 47.310	—0.074	
	2 01 53.299	—1 06.063	2 00 47.236	....	2 05 00.000	— 4 12.689	2 00 27.311	—0.075	—0.077
Nov. 12, clock	1 53 15.000	—1 06.065	1 52 08.935	10 21 55.000	....	+15 30 13.997	1 52 08.997	—0.062	
	1 56 16.000	—1 06.065	1 55 09.935	10 24 55.500	....	+15 30 14.497	1 55 09.997	—0.062	
	2 05 14.000	—1 06.063	1 04 07.937	10 33 52.000	....	+15 30 15.979	2 04 07.979	—0.042	
	2 08 15.000	—1 06.062	1 07 08.938	10 36 52.500	....	+15 30 16.479	2 07 08.979	—0.041	—0.052
									—0.065

Mean, both directions, November 5 .... +.018
Mean, both directions, November 11 .... —.042
Mean, both directions, November 12 .... —.065

Mean of all .... —.030

Telegraphic longitude—1875.

DETROIT—CHARLOTTE.

Signals sent from	Detroit.			Charlotte.				Difference.	Mean each night.
	Detroit clock.	Correction.	Sidereal time.	Mean solar chronometer.	Sidereal chronometer.	Correction.	Sidereal time.		
	h. m. s.	*m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*m. s.*	*h. m. s.*	*m. s.*	*m. s.*
July 20, Charlotte	18 46 16.574	−1 17.391	18 44 59.183	....	18 45 00.000	−7 08.696	18 37 51.304	7 7.879	
	19 17 16.547	−1 17.402	19 15 59.145	....	19 16 00.000	−7 08.707	19 08 51.293	7 7.852	
								7 7.866	
July 20, Detroit	19 21 20.000	−1 17.404	19 20 02.596	11 25 31.500	....	....	19 12 54.816	7 7.780	
	19 24 38.000	−1 17.405	19 23 20.595	11 28 49.000	....	....	19 16 12.850	7 7.745	
	19 27 35.000	−1 17.406	19 26 17.594	11 31 45.500	....	....	19 19 19.827	7 7.767	
	19 36 30.000	−1 17.409	19 35 12.591	11 40 39.000	....	....	19 28 04.769	7 7.822	
	19 39 32.000	−1 17.410	19 38 14.590	11 43 40.500	....	....	19 31 16.759	7 7.831	
								7 7.789	7 7.823
July 24, Charlotte	20 46 22.994	−1 17.320	20 45 05.674	....	20 45 00.000	−7 02.218	20 37 57.782	7 7.892	
	20 47 22.991	−1 17.320	20 46 05.671	....	20 46 00.000	−7 02.219	20 38 57.781	7 7.890	
	21 17 22.983	−1 17.303	21 16 05.680	....	21 16 00.000	−7 02.237	21 08 57.763	7 7.917	
	21 18 22.980	−1 17.303	21 17 05.677	....	21 17 00.000	−7 02.238	21 09 57.762	7 7.915	
								7 7.903	
July 24, Detroit	21 03 24.000	−1 17.311	21 02 06.689	12 51 35.500	....	....	20 54 58.862	7 7.827	
	21 06 27.000	−1 17.309	21 05 09.691	12 54 38.000	....	....	20 58 01.860	7 7.831	
	21 24 37.000	−1 17.299	21 23 19.701	13 12 45.000	....	....	21 16 11.826	7 7.875	
	21 27 40.000	−1 17.297	21 26 22.703	13 15 47.500	....	....	21 19 14.824	7 7.879	
								7 7.853	7 7.878

	m. s.
Mean of results, both directions, July 20	7 7.823
Mean of results, both directions, July 24	7 7.878
Mean	7 7.851
Relative personal equation	+ .006
Charlotte west of Detroit	7 7 857

Telegraphic longitude—1875.

DETROIT—MARSHALL.

Signals sent from—	Detroit.			Marshall.				Difference.	Mean each night.
	Detroit clock.	Correction.	Sidereal time.	Mean solar chronometer.	Sidereal chronometer.	Correction.	Sidereal time.		
	h. m. s.	*m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*m. s.*	*m. s.*
Aug. 13, Marshall	20 33 41.963	—1 18.424	20 32 23.539	....	20 32 00.000	— 7 15.513	20 24 44.487	7 39.052	
	20 34 41.965	—1 18.424	20 33 23.541	....	20 33 00.000	— 7 15.513	20 25 44.487	7 39.054	
	20 57 41.981	—1 18.436	20 56 23.545	....	20 56 00.000	— 7 15.521	20 48 44.479	7 39.066	
								7 39.057	
Aug. 13, Detroit	20 45 55.000	—1 18.430	20 44 36.570	11 15 20.500	....	+ 9 21 37.040	20 36 57.540	7 39.030	
	20 48 57.000	—1 18.431	20 47 38.569	11 18 22.000	....	+ 9 21 37.538	20 39 59.538	7 39.031	
	21 03 58.000	—1 18.438	21 02 39.562	11 33 20.500	....	+ 9 21 39.995	20 55 00.495	7 39.067	
	21 06 58.000	—1 18.440	21 05 39.560	11 36 20.000	....	+ 9 21 40.487	20 58 00.487	7 39.073	
								7 39.050	7 39.054
Aug. 24, Marshall	20 33 56.796	—1 19.764	20 32 37.032	....	20 32 00.000	— 7 02.012	20 24 57.988	7 39.044	
	20 34 56.795	—1 19.764	20 33 37.031	....	20 33 00.000	— 7 02.011	20 25 57.989	7 39.042	
	21 05 56.800	—1 19.762	21 04 37.038	....	21 04 00.000	— 7 01.987	20 56 58.013	7 39.025	
	21 08 56.808	—1 19.762	21 07 37.046	....	21 07 00.000	— 7 01.985	20 59 58.015	7 39.031	
	21 09 56.804	—1 19.762	21 08 37.042	....	21 08 00.000	— 7 01.984	21 00 58.016	7 39.026	
								7 39.034	
Aug, 24, Detroit	20 54 27.000	—1 19.763	20 53 07.237	10 40 34.500	....	+10 04 53.784	20 45 28.284	7 38.953	
	21 00 29.000	—1 19.763	20 59 09.237	10 46 35.500	....	+10 04 54.772	20 51 30.272	7 38.965	
	21 12 32.000	—1 19.763	21 11 12.237	10 58 36.500	....	+10 04 56.753	21 03 33.253	7 38.984	
	21 15 33.000	—1 19.762	21 14 13.238	11 01 37.000	....	+10 04 57.249	21 06 34.249	7 38.989	
								7 38.973	7 39.003

	m. s.
Mean, both directions, August 13	7 39.054
Mean, both directions, August 24	7 39.003
Mean of all	7 39.028
Relative personal equation	+ .006
Marshall west of Detroit	7 39.034

Telegraphic longitude—1875.

DETROIT—KALAMAZOO.

Signals sent from—	Detroit.			Kalamazoo.				Difference.	Mean each night.
	Detroit clock.	Correction.	Sidereal time.	Mean solar chronometer.	Sidereal chronometer.	Correction.	Sidereal time.		
	h. m. s.	*m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*m. s.*	*m. s.*
Aug. 30, Kalamazoo	22 20 00.542	—1 20.638	22 18 39.904	....	22 18 00.000	— 9 28.218	22 08 31.782	10 08.122	
	22 21 00.525	—1 20.639	22 19 39.886	....	22 19 00.000	— 9 28.217	22 09 31.783	08.103	
	22 41 00.595	—1 20.647	22 39 39.948	....	22 39 00.000	— 9 28.209	22 29 31.791	08.157	
								10 08.127	
Aug. 30, Detroit	22 27 21.000	—1 20.642	22 26 00.358	11 49 35.500	....	+10 26 16.749	22 15 52.249	10 08.109	
	22 30 23.000	—1 20.643	22 29 02.357	11 52 37.000	....	+10 26 17.248	22 18 54.248	08.109	
	22 48 38.000	—1 20.651	22 47 17.349	12 10 49.000	....	+10 26 20.243	22 37 09.243	08.106	
	22 51 40.000	—1 20.652	22 50 19.348	12 13 50.500	....	+10 26 20.741	22 40 11.241	08.107	
								10 08.108	10 08.118
Aug. 31 Kalamazoo	22 30 41.123	—1 20.779	22 29 20.344	....	22 30 00.000	— 10 47.797	22 19 12.203	10 08.141	
	22 31 41.128	—1 20.779	22 30 20.349	....	22 31 00.000	— 10 47.797	22 20 12.203	08.146	
	22 44 41.164	—1 20.779	22 43 20.385	....	22 44 00.000	— 10 47.796	22 33 12.204	08.181	
	22 45 41.161	—1 20.780	22 44 20.381	....	22 45 00.000	— 10 47.796	22 34 12.204	08.177	
								10 08.161	
Aug. 31, Detroit	22 34 52.000	—1 20.779	22 33 31.221	11 53 08.000	....	+10 30 15.138	22 23 23.138	10 08.083	
	22 37 52.000	—1 20.779	22 36 31.221	11 56 07.500	....	+10 30 15.625	22 26 23.125	08.096	
	22 49 55.000	—1 20.780	22 48 34.220	12 08 08.500	....	+10 30 17.587	22 38 26.087	08.133	
	22 52 59.000	—1 20.780	22 51 38.220	12 11 12.000	....	+10 30 18.085	22 41 30.085	08.135	
								10 08.112	10 08.136
Mean both nights									10 08.127
Relative personal equation									+ .006
Kalamazoo west of Detroit									10 08.133

Telegraphic longitude—1875.

DETROIT—PAW PAW.

Signals sent from—	Detroit. Detroit clock.	Detroit. Correction.	Detroit. Sidereal time.	Paw Paw. Mean solar chronometer.	Paw Paw. Sidereal chronometer.	Paw Paw. Correction.	Paw Paw. Sidereal time.	Difference.	Mean each night.
	h. m. s.	*m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*m. s.*	*m. s.*
Sept. 23, Paw Paw	23 28 29.462	−1 20.733	23 27 08.729	....	23 27 00.000	− 11 11.318	23 15 48.682	11 20.047	
	23 29 29.462	−1 20.733	23 28 08.729	....	23 28 00.000	− 11 11.316	23 16 48.684	11 20.045	
	23 43 29.485	−1 20.727	23 42 08.758	....	23 42 00.000	− 11 11.294	23 30 48.706	20.052	
	23 44 29.485	−1 20.727	23 43 08.758	....	23 43 00.000	− 11 11.292	23 31 48.708	20.050	
								11 20.049	
Sept. 23, Detroit	23 33 10.000	−1 20.731	23 31 49.269	11 20 25.500	....	+12 00 03.713	23 20 29.213	11 20.056	
	23 36 11.000	−1 20.730	23 34 50.270	11 23 26.000	....	+12 00 04.211	23 23 30.211	20.059	
	23 48 14.000	−1 20.725	23 46 53.275	11 35 27.000	....	+12 00 06.205	23 35 33.205	20.070	
	23 51 14.000	−1 20.724	23 49 53.276	11 38 26.500	....	+12 00 06.701	23 38 33.201	20.075	
								11 20.065	11 20.057
Sept. 24, Paw Paw	22 49 31.169	−1 20.489	22 48 10.680	....	22 48 00.000	− 11 09.410	22 36 50.590	11 20.090	
	22 50 31.169	−1 20.489	22 49 10.680	....	22 49 00.000	− 11 09.409	22 37 50.591	20.089	
	23 05 31.189	−1 20.490	23 04 10.699	....	23 04 00.000	− 11 09.401	22 52 50.599	20.100	
								20.093	
Sept. 24, Detroit	22 52 21.000	−1 20.489	22 51 00.511	10 35 45.000	....	+12 03 55.399	22 39 40.399	11 20.112	
	22 55 22.000	−1 20.490	22 54 01.510	10 38 45.500	....	+12 03 55.894	22 42 41.394	11 20.116	
	22 58 23.000	−1 20.490	22 57 02.510	10 41 46.000	....	+12 03 56.389	22 45 42.389	20.121	
	23 07 27.000	−1 20.490	23 06 06.510	10 50 48.500	....	+12 03 57.878	22 54 46 378	20.132	
	23 10 27.000	−1 20.491	23 09 06.509	10 53 48.000	....	+12 03 58.371	22 57 46.371	20.138	
	23 13 29.000	−1 20.491	23 12 08.509	10 56 49.500	....	+12 03 58.870	23 00 48.370	20.139	
								11 20.126	11 20.110
Mean both nights									11 20.083
Relative personal equation									+ .006
Paw Paw west of Detroit									11 20.089

Telegraphic longitude—1875.

DETROIT—STANTON.

Signals sent from—	Detroit.			Stanton.				Differenee.	Mean each night.
	Detroit clock.	Correction.	Sidereal time.	Mean solar chronometer.	Sidereal chronometer.	Correction.	Sidereal time.		
	h. m. s.	*m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*m. s.*	*m. s.*
Oct. 13, Stanton	0 18 37.430	—1 16.909	0 17 20.521	....	0 19 00.000	—9 47.093	0 09 12.907	8 07.614	
	0 19 37.431	—1 16.908	0 18 20.523	....	0 20 00.000	—9 47.091	0 10 12.909	07.614	
	0 34 37.458	1 16.899	0 33 20.559	....	0 35 00.000	--9 47.061	0 25 12.939	07.620	
								8 07.616	
Oct. 13, Detroit	0 22 43.000	—1 16.906	0 21 26.094	10 50 45.000	....	+ .437	0 13 18.437	8 07.657	
	0 25 44.000	—1 16.905	0 24 27.095	10 53 45.500	....	+ .935	0 16 19.435	07.660	
	0 37 47.000	—1 16.897	0 36 30.103	11 05 46.500	....	+ .925	0 28 22.425	07.678	
	0 40 47.000	—1 16.896	0 39 30.104	11 08 46.000	....	+ .420	0 31 22.420	07.684	
								8 07.670	8 07.643
Oct. 20, Stanton	23 22 1.795	—1 13.992	23 20 47.803	....	23 22 00.000	—9 19.897	23 12 40.103	8 07.700	
	0 19 1.813	—1 13.975	0 17 47.838	....	0 19 00.000	—9 19.853	0 09 40.147	07.691	
								8 07.695	
Oct. 20, Detroit	23 53 19.000	—1 13.983	23 52 5.017	9 53 35.000	....	....	23 43 57.353	8 07.664	
	23 56 21.000	—1 13.982	23 55 7.018	9 56 36.500	....	....	23 46 59.349	07.669	
	0 23 21.000	—1 13.974	0 22 7.026	10 23 32.000	....	....	0 13 59.267	07.759	
	0 26 22.000	—1 13.973	0 25 8.027	10 26 32.500	....	....	0 17 00.260	07.767	
								8.07.715	8 07.70
Mean both nights									8 07.674
Relative personal equation									+ .006
Stanton west of Detroit									8 07.680

Relative personal equation—Lieutenant Lockwood and Lieutenant Bailey—1875.

Signals sent from—	Clock.			Chronometer.				Difference.	Mean each night.
	Detroit clock.	Correction.	Sidereal time.	Mean solar chronometer.	Sidereal chronometer.	Correction.	Sidereal time.		
	h. m. s.	*m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*s.*	*s.*
May 10, sidereal chronometer.	14 27 24.160	− 1 06.990	14 26 17.170	....	14 28 16.000	− 0 1 58.992	14 26 17.008	+ 0.162	
	14 44 08.071	− 1 07.012	14 43 01.059	....	14 45 00.000	− 0 1 59.031	14 43 00.969	+ 0.090	
	14 45 08.077	− 1 07.013	14 44 01.064	....	14 46 00.000	− 0 1 59.033	14 44 00.967	+ 0.097	
								+ 0.116	
May 10, clock	14 34 15.000	− 1 06.999	14 33 08.001	11 51 02.000	....	+ 2 42 05.947	14 33 07.947	+ 0.054	
	14 37 22.000	− 1 07.003	14 36 14.997	11 54 08.500	....	+ 2 42 06.442	14 36 14.942	+ 0.055	
	14 40 14.000	− 1 07.007	14 39 06.993	11 57 00.000	....	+ 2 42 06.900	14 39 06.900	+ 0.093	
	14 55 24.000	− 1 07.027	14 54 16.973	12 12 07.500	....	+ 2 42 09.313	14 54 16.813	+ 0.160	
	14 58 51.000	− 1 07.031	14 57 43.969	12 15 34.000	....	+ 2 42 09.864	14 57 43.864	+ 0.105	
								+ 0.093	+ 0.105
May 12, sidereal chronometer	14 31 03.790	− 1 07.330	14 29 56.460	....	14 32 00.000	− 0 2 03.648	14 29 56.352	+ 0.108	
	14 32 03.791	− 1 07.330	14 30 56.461	....	14 33 00.000	− 0 2 03.649	14 30 56.351	+ 0.111	
	15 09 03.748	− 1 07.330	15 07 56.418	....	15 10 00.000	− 0 2 03.705	15 07 56.295	+ 0.123	
	15 10 03.747	− 1 07.330	15 08 56.417	....	15 11 00.000	− 0 2 03.706	15 08 56.294	+ 0.123	
								+ 0.116	
May 12, clock	14 35 30.000	− 1 07.330	14 34 22.670	11 44 34.500	....	+ 2 49 48.083	14 34 22.583	+ 0.087	
	14 38 30.000	− 1 07.330	14 37 22.670	11 47 34.000	....	+ 2 49 48.565	14 37 22.565	+ 0.105	
	14 41 39.000	− 1 07.330	14 40 31.670	11 50 42.500	....	+ 2 49 49.071	14 40 31.571	+ 0.099	
	15 22 01.000	− 1 07.330	15 20 53.670	12 30 58.000	....	+ 2 49 55.558	15 20 53.558	+ 0.112	
	15 25 02.000	− 1 07.330	15 23 54.670	12 33 58.500	....	+ 2 49 56.042	15 23 54.542	+ 0.128	
								+ 0.106	+ 0.111
May 15, sidereal chronometer.	15 21 56.904	− 1 07.650	15 20 49.254	....	15 23 00.000	− 0 2 10.785	15 20 49.215	+ 0.039	
	15 22 56.901	− 1 07.650	15 21 49.251	....	15 24 00.000	− 0 2 10.787	15 21 49.213	+ 0.038	
	15 23 56.904	− 1 07.650	15 22 49.254	....	15 25 00.000	− 0 2 10.788	15 22 49.212	+ 0.042	
								+ 0.040	
May 15, clock	15 20 47.500	− 1 07.650	15 19 39.850	12 18 12.000	....	+ 3 01 27.853	15 19 39.853	− 0.003	+ 0.019
Mean of results May 10, 12, and 15									+ 0.078
Mean of results November 4, 5, and 10									+ 0.181
Mean of all									+ 0.130
Difference of time between piers									− .004
Lieutenant Bailey observes later than Lieutenant Lockwood									+ 0.126

Relative personal equation—Lieutenants Lockwood and Bailey—1875.

Signals sent from—	Clock.			Sidereal chronometer.				Difference.	Mean each night.
	Clock.	Correction.	Sidereal time.	M. S. chron.	Correction.	Sidereal chron.	Sidereal time.		
	h. m. s.	*m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*s.*	*s.*
Nov. 4, Detroit clock	1 53 34.000	— 1 09.770	1 52 24.230	10 54 49.500	....	— 9 02 25.430	1 52 24.070	+ 0.160	
	1 56 38.000	— 1 09.770	1 55 28.230	10 57 53.000	....	— 9 02 24.932	1 55 28.068	+ 0.162	
	2 02 50.000	— 1 09.770	2 01 40.230	11 04 04.000	....	— 9 02 23.927	2 01 40.073	+ 0.157	
	2 05 53.000	— 1 09.769	2 04 43.231	11 07 06.500	....	— 9 02 23.428	2 04 43.072	+ 0.159	
								+ 0.1595	
Nov. 4, sidereal chronometer	1 49 35.008	— 1 09.770	1 48 25.238	....	1 47 53.000	+ 0 00 32.085	1 48 25.085	+ 0.153	
	1 50 34.993	— 1 09.770	1 49 25.223	....	1 48 53.000	+ 0 00 32.082	1 49 25.082	+ 0.141	
	1 59 04.981	— 1 09.770	1 57 55.211	....	1 57 23.000	+ 0 00 32.059	1 57 55.059	+ 0.156	
	2 00 04.991	— 1 09.770	1 58 55.221	....	1 58 23.000	+ 0 00 32.056	1 58 55.056	+ 0.165	
								+ 0.1537	+ 0.1566
Nov. 5, Detroit clock	2 01 38.000	— 1 09.089	2 00 28.911	10 58 58.000	....	— 8 58 29.372	2 00 28.628	+ 0.283	
	2 04 47.000	— 1 09.087	2 03 37.913	11 02 06.500	....	— 8 58 28.861	2 03 37.639	+ 0.274	
	2 10 57.000	— 1 09.083	2 09 47.917	11 08 15.500	....	— 8 58 27.862	2 09 47.638	+ 0.279	
	2 14 01.000	— 1 09.081	2 12 51.919	11 11 19.000	....	— 8 58 27.363	2 12 51.637	+ 0.282	
								+ 0.2795	
Nov. 5, sidereal chronometer .	1 58 01.754	— 1 09.091	1 56 52.663	....	1 56 23.000	+ 0 00 29.448	1 56 52.448	+ 0.215	
	1 59 01.748	— 1 09.091	1 57 52.657	....	1 57 23.000	+ 0 00 29.446	1 57 52.446	+ 0.211	
	2 06 31.791	— 1 09.086	2 05 22.705	....	2 04 53.000	+ 0 00 29.426	2 05 22.426	+ 0.279	
	2 07 31.789	— 1 09.085	2 06 22.704	....	2 05 53.000	+ 0 00 29.423	2 06 22.423	+ 0.281	
								+ 0.2465	+ 0.2630
Nov. 10, Detroit clock	1 05 21.000	— 1 06.752	1 04 14.248	9 43 20.000	....	— 8 39 05.912	1 04 14.088	+ 0.160	
	1 08 37.000	— 1 06.751	1 07 30.249	9 46 35.500	....	— 8 39 05.381	1 07 30.119	+ 0.130	
	1 14 55.000	— 1 06.748	1 13 48.252	9 52 52.500	....	— 8 39 04.358	1 13 48.142	+ 0.110	
	1 17 57.000	— 1 06.746	1 16 50.254	9 55 54.000	....	— 8 39 03.864	1 16 50.136	+ 0.118	
								+ 0.1295	
Nov. 10, sidereal chronometer	1 02 47.803	— 1 06.754	1 01 41.049	....	1 01 22.500	+ 0 00 18.437	1 01 40.937	+ 0.112	
	1 03 47.780	— 1 06.753	1 02 41.027	....	1 02 22.500	+ 0 00 18.434	1 02 40.934	+ 0.093	
	1 10 47.793	— 1 06.750	1 09 41.043	....	1 09 22.500	+ 0 00 18.412	1 09 40.912	+ 0.131	
	1 11 47.800	— 1 06.749	1 10 41.051	....	1 10 22.500	+ 0 00 18.409	1 10 40.909	+ 0.142	
								+ 0.1195	+ 0.1245
Mean of all..........									+ 0.181

Telegraphic longitude—1875.

DETROIT—HOWELL.

Signals sent from—	Detroit.			Howell.				Difference.	Mean each night.
	Detroit clock.	Correction.	Sidereal time.	Mean solar chronometer.	Sidereal chronometer.	Correction.	Sidereal time.		
	h. m. s.	*m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m s.*	*m. s.*	*m. s.*
June 18, Howell	17 26 06.696	—1 11.076	17 20 55.620	....	17 30 00.000	—0 12 35.213	17 17 24.787	3 30.833	
	17 54 06.700	—1 11.096	17 52 55.604	....	18 02 00.000	—0 12 35.200	17 49 24.800	3 30.804	
								3 30.819	
June 18, Detroit	17 26 34.000	—1 11.079	17 25 22.921	11 36 05.000	....	+5 45 47.096	17 21 52.096	3 30 825	
	17 29 40.000	—1 11.081	17 28 28.919	11 39 10.500	....	+5 45 47.590	17 24 58.090	3 30.829	
	17 42 04.000	—1 11.089	17 40 52.911	11 51 32.500	....	+5 45 49.568	17 37 22.068	3 30.843	
	17 45 09.000	—1 11.090	17 43 57.910	11 54 37.000	....	+5 45 50.060	17 40 27.060	3 30.850	
	17 57 39.000	—1 11.098	17 56 27.902	12 07 05.000	....	+5 45 52.055	17 52 57.055	3 30.847	
	18 00 49.000	—1 11.100	17 59 37.900	12 10 14.500	....	+5 45 52.562	17 56 07.062	3 30.838	
	18 03 55.000	—1 11.102	18 02 43.898	12 13 20.000	....	+5 45 53.057	17 59 13.057	3 30.841	
								3 30.839	3 30.829
June 19, Howell	17 17 08.321	—1 11.033	17 15 57.288	....	17 25 00.000	—0 12 33.542	17 12 26.458	3 30.830	
	17 18 08.322	—1 11.034	17 16 57.288	....	17 26 00.000	—0 12 33.542	17 13 26.458	3 39.830	
								3.30.830	
June 19, Detroit	17 22 17.000	—1 11.036	17 21 05.964	11 27 58.000	....	+5 49 37.110	17 17 35.110	3 30.854	
	17 25 24.000	—1 11.037	17 24 12.963	11 31 04.500	....	+5 49 37.606	17 20 42.106	3 30.857	
	17 28 32.000	—1 11.039	17 27 20.961	11 34 12.000	....	+5 49 38.105	17 23 50.105	3 30.856	
	17 40 56.000	—1 11.045	17 39 44.955	11 46 34.000	....	+5 49 40.079	17 36 14.079	3 30.876	
	17 44 13.000	—1 11.046	17 43 01.954	11 49 50.500	....	+5 49 40.601	17 39 31.101	3 30.853	
	17 47 20.000	—1 11.048	17 46 08.952	11 52 57.000	....	+5 49 41.097	17 42 38.097	3 30.855	
									3 30.844
Mean both nights									3 30.836
Relative personal equation									— .126
Howell west of Detroit									3 30.710

Telegraphic longitude—1875.

DETROIT—LANSING.

Signals sent from—	Detroit.			Lansing.				Difference.	Mean each night.
	Detroit clock.	Correction.	Sidereal time.	Mean solar chronometer.	Sidereal chronometer.	Correction.	Sidereal time.		
	h. m. s.	*m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*m. s.*	*m. s.*
July 13, Lansing	18 38 06.299	—1 16.264	18 36 50.035	....	18 45 13.500	—0 14 24.702	18 30 48.798	6 01.237	
	18 38 52.797	—1 16.264	18 37 36.533	....	18 46 00.000	—0 14 24.701	18 31 35.299	01.234	
	19 27 52.903	—1 16.271	19 26 36.632	....	19 35 00.000	—0 14 24.614	19 20 35.356	01.276	
	19 28 52.904	—1 16.272	19 27 36.632	....	19 36 00.000	—0 14 24.643	19 21 35.357	01.275	
								6 01.256	
July 13, Detroit	19 10 49.000	—1 16.269	19 09 32.731	11 43 45.000	....	+7 19 46.548	19 03 31.548	6 01.183	
	19 13 53.000	—1 16.269	19 12 36.731	11 46 48.500	....	+7 19 47.039	19 06 35.539	01.192	
	19 16 57.000	—1 16.270	19 15 40.730	11 49 52.000	....	+7 19 47.528	19 09 39.528	01.202	
	19 48 16.000	—1 16.275	19 46 59.725	12 21 06.000	....	+7 19 52.536	19 40 58.536	01.189	
								6 01.191	6 01.224
July 19, Lansing	19 18 00.796	—1 17.346	19 16 43.450	....	19 24 56.000	—0 14 13.880	19 10 42.120	6 01.330	
	19 19 00.795	—1 17.346	19 17 43.449	....	19 25 56.000	—0 14 13.878	19 11 42.122	01.327	
	19 56 00.811	—1 17.348	19 54 43.463	....	20 02 56.000	—0 14 13.809	19 48 42.191	01.272	
	19 57 00.808	—1 17.348	19 55 43.460	....	20 03 56.000	—0 14 13.807	19 49 42.193	01.267	
								6 01.299	
July 19, Detroit	19 43 44.390	—1 17.347	19 42 27.043	....	19 50 39.458	—0 14 13.832	19 36 25.626	6 01.417	
	19 47 08.373	—1 17.348	19 45 51.025	....	19 54 03.415	—0 14 13.825	19 39 49.590	01.435	
	19 50 26.033	—1 17.348	19 49 08.685	....	19 57 21.080	—0 14 13.819	19 43 07.261	01.424	
								6 01.425	6 01.362
July 26, Lansing	20 35 16.907	—1 17.438	20 33 59.469	....	20 42 00.000	—0 14 01.696	20 27 58.304	6 01.165	
	20 36 16.916	—1 17.438	20 34 59.478	....	20 43 00.000	—0 14 01.695	20 28 58.305	01.173	
	20 51 16.922	—1 17.435	20 49 59.487	....	20 58 00.000	—0 14 01.672	20 43 58.328	01.159	
	20 52 16.929	—1 17.435	20 50 59.494	....	20 59 00.000	—0 14 01.670	20 44 58.330	01.164	
								6 01.165	

July 26, Detroit	20 39 23.000	−1 17.437	20 38 05.563	14 18 34.000	....	+6 13 30.455	20 32 04.455	6 01.108	
	20 42 27.000	−1 17.436	20 41 09.564	14 21 37.500	....	+6 13 30.952	20 35 08.452	01.112	
	20 54 44.000	−1 17.434	20 53 26.566	14 33 52.500	....	+6 13 32.946	20 47 25.446	01.120	
	20 57 57.000	−1 17.434	20 56 39.566	14 37 05.000	....	+6 13 33.469	20 50 38.469	01.097	
	21 00 58.000	−1 17.433	20 59 40.567	14 40 05.500	....	+6 13 33.958	20 53 39.458	01.109	
								6 01.109	6 01.137
Weighted mean, (see note below)									6 01.198
Relative personal equation									— .726
Lansing west of Detroit									6 01.072

NOTE.—On July 19, the mean solar chronometer at Lansing was disabled, and only arbitrary signals were received there; these signals were recorded on the Detroit chronograph, and the time of receiving them at Lansing estimated by the observer there from his sidereal chronometer. As Lieutenant Bailey's arbitrary personal equation in estimating the exact instant of their receipt enters into these results, and as there are no data for determining such equation, the signals sent *from* Lansing only, on that night, are used in determining the final difference of longitude. The double wave and armature time for July 13 and July 26 is found to be $0^s.065$ and $0^s.056$ respectively. In the summary, the difference of longitude as determined by signals from Lansing is corrected by one-half the mean of the above, and the final difference of longitude determined by taking the mean of the three nights, giving July 19 the weight 0.5.

Telegraphic longitude—1875.

DETROIT—HASTINGS.

Signals sent from—	Detroit.			Hastings.				Difference.	Mean each night.
	Detroit clock.	Correction.	Sidereal time.	Mean solar chronometer.	Sidereal chronometer.	Correction.	Sidereal time.		
	h. m. s.	*m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*m. s.*	*m. s.*
July 30, Detroit	21 00 43.000	−1 17.357	20 59 25.643	14 24 18.000	....	+6 26 10.394	20 50 28.394	8 57.249	
	21 03 50.000	−1 17.357	21 02 32.643	14 27 24.500	....	+6 26 10.893	20 53 35.393	57.250	
	21 13 01.000	−1 17.358	21 11 43.642	14 36 34.000	....	+6 26 12.363	21 02 46.363	57.279	
	21 16 06.000	−1 17.358	21 14 48.642	14 39 38.500	....	+6 26 12.857	21 05 51.357	57.285	
	21 19 12.000	−1 17.358	21 17 54.642	14 42 44.000	....	+6 26 13.352	21 08 57.352	57.290	
								8 57.271	
July 30, Hastings	20 36 22.860	−1 17.355	20 35 05.505	....	20 43 00.000	−0 16 51.706	20 26 08.294	8 57.211	
	20 37 22.880	−1 17.355	20 36 05.525	....	20 44 00.000	−0 16 51.705	20 27 08.295	57.230	
	20 53 22.920	−1 17.356	20 52 05.564	....	21 00 00.000	−0 16 51.694	20 43 08.306	57.258	
	20 54 22.920	−1 17.356	20 53 05.564	....	21 01 00.000	−0 16 51.694	20 44 08.306	57.258	
								8 57.239	8 57.255
Aug. 7, Detroit	20 37 35.000	−1 17.832	20 36 17.168	13 30 15.000	....	+6 57 05.235	20 27 20.235	8 56.933	
	20 40 41.000	−1 17.831	20 39 23.169	13 33 20.500	....	+6 57 05.740	20 30 26.240	56.929	
	20 52 53.000	−1 17.823	20 51 35.177	13 45 30.500	....	+6 57 07.726	20 42 38.226	56.951	
	20 56 05.000	−1 17.821	20 54 45.179	13 48 40.000	....	+6 57 08.242	20 45 48.242	56.937	
								8 56.938	
Aug. 7, Hastings	20 32 35.970	−1 17.835	20 31 18.135	....	20 39 00.000	−0 16 38.807	20 22 21.193	8 56.942	
	20 33 35.980	−1 17.835	20 32 18.145	....	20 40 00.000	−0 16 38.806	20 23 21.194	56.951	
	20 47 35.950	−1 17.826	20 46 18.124	....	20 54 00.000	−0 16 38.792	20 37 21.208	56.916	
	20 48 35.970	−1 17.826	20 47 18.144	....	20 55 00.000	−0 16 38.791	20 38 21.209	56.935	
								8 56.936	8 56.937
Aug. 12, Detroit	20 30 13.000	−1 18.270	20 28 54.730	13 03 30.000	....	+7 16 27.650	20 19 57.650	8 57.080	
	20 39 29.000	−1 18.270	20 38 10.730	13 12 44.500	....	+7 16 29.151	20 29 13.651	57.079	
	20 42 30.000	−1 18.270	20 41 11.730	13 15 45.000	....	+7 16 29.639	20 32 14.639	57.091	
	20 45 38.000	−1 18.270	20 44 19.730	13 18 52.500	....	+7 16 30.146	20 35 22.646	57.084	
								8 57.083	

Aug., Hastings	20 22 47.500	—1 18.270	20 21 29.230	....	20 29 00.000	—0 16 27.934	20 12 32.066	8 57.164	
	20 23 47.500	—1 18.270	20 22 29.230	....	20 30 00.000	—0 16 27.932	20 13 32.068	57.162	
	20 36 47.500	—1 18.270	20 35 29.230	....	20 43 00.000	—0 16 27.915	20 26 32.085	57.145	
	20 37 47.500	—1 18.270	20 36 29.230	....	20 44 00.000	—0 16 27.913	20 27 32.087	57.143	
								8 57.153	8 57.118
Mean of all									8 57.103
Relative personal equation									— .126
Hastings west of Detroit									8 56.977

Telegraphic longitude—1875.

DETROIT AND JACKSON.

Signals sent from—	Detroit.			Jackson.				Difference in long.	Mean in both directions.
	Detroit clock.	Correction.	Sidereal time.	Mean solar chronometer.	Sidereal chronometer.	Correction.	Sidereal time.		
	h. m. s.	*m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*m. s.*	*m. s.*
Aug. 28, Jackson	22 40 57.314	—1 20.352	22 39 36.962	....	22 34 37.500	— 0 26.481	22 34 11.019	5 25.943	
	22 41 27.297	—1 20.352	22 40 06.945	....	22 35 07.500	— 0 26.482	22 34 41.018	5 25.927	
	22 22 27.397	—1 20.346	22 21 07.051	....	22 16 07.500	— 0 26.438	22 15 41.062	5 25.989	
	22 22 57.382	—1 20.346	22 21 37.036	....	22 16 37.500	— 0 26.439	22 16 11.061	5 25.975	
								5 25.958	
Aug. 28, Detroit	22 28 32.000	—1 20.348	22 27 11.652	11 54 57.000	....	+10 26 48.730	22 21 45.730	5 25.922	
	22 31 46.000	—1 20.349	22 30 25.651	11 58 10.500	....	+10 26 49.257	22 24 59.757	5 25.894	
	22 44 08.000	—1 20.354	22 42 47.646	12 10 30.500	....	+10 26 51.274	22 37 21.774	5 25.872	
	22 47 15.000	—1 20.355	22 45 54.645	12 13 37.000	....	+10 26 51.784	22 40 28.784	5 25.861	
	22 50 19.000	—1 20.356	22 48 58.644	12 16 40.500	....	+10 26 52.283	22 43 32.783	5 25.861	
								5 25.882	5 25.920
Aug. 30, Jackson	22 37 04.757	—1 20.642	22 35 44.115	....	22 30 53 000	— 0 34.965	22 30 18.035	5 26.080	
	22 37 34.777	—1 20.642	22 36 14.135	....	22 31 23.000	— 0 34.966	22 30 48.034	5 26.101	
	22 38 04.769	—1 20.642	22 36 44.127	....	22 31 53.000	— 0 34.968	22 31 18.032	5 26.095	
	22 38 34.786	—1 20.642	22 37 14.144	....	22 32 23.000	— 0 34.970	22 31 48.030	5 26.114	
								5 26.097	
Aug. 30, Detroit	22 24 56.000	—1 20.637	22 23 35.363	11 43 35.500	....	+10 34 33.759	22 18 09.259	5 26.104	
	22 28 01.000	—1 20.638	22 26 40.362	11 46 40.000	....	+10 34 34.261	22 21 14.261	5 26.101	
	22 31 07.000	—1 20.639	22 29 46.361	11 49 45.500	....	+10 34 34.764	22 24 20.264	5 26.097	
	22 46 19.000	—1 20.646	22 44 58.354	12 04 55.000	....	+10 34 37.231	22 39 32.231	5 26 123	
	22 49 30.000	—1 20.647	22 48 09.355	12 08 05.500	....	+10 34 37.746	22 42 43.246	5 26.107	
								5 26.106	5 26.101

	m. s.
August 28, mean of signals, both directions	5 25.920
August 30, mean of signals, both directions	5 26.101
Mean of both nights	5 26.010
Personal equation	— .126
Jackson west of Detroit	5 25.884

Telegraphic longitude—1875.

DETROIT—ALLEGAN.

Signals sent from—	Detroit.			Allegan.				Difference.	Mean both directions.
	Detroit clock.	Correction.	Sidereal time.	Mean solar chronometer.	Sidereal chronometer.	Correction.	Sidereal time.		
	h. m. s.	*m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*m. s.*	*s.*
Sept. 23, Allegan	22 26 22.285	—1 20.758	22 25 01.527	...	22 21 37.500	— 7 48.402	22 13 49.098	11 12.429	
	22 29 08.319	—1 20.757	22 27 47.562	...	22 23 23.500	— 7 48.409	22 15 35.091	11 12.471	
	22 52 51.694	—1 20.748	22 51 30.946	...	22 48 07.000	— 7 48.499	22 40 18.501	11 12.445	
	22 53 49.663	—1 20.747	22 52 28.916	...	22 49 05.000	— 7 48.503	22 41 16.497	11 12.419	
								11 12.441	
Sept. 23, Detroit	22 32 46.000	—1 20.756	22 31 25.244	10 18 00.000	...	+12 02 12.825	22 20 12.825	11 12.419	
	22 35 52.000	—1 20.755	22 34 31.245	10 21 05.500	...	+12 02 13.328	22 23 18.828	11 12.417	
	22 45 08.000	—1 20.751	22 43 47.249	10 30 20.000	...	+12 02 14.834	22 32 34.834	11 12.415	
	22 57 45.000	—1 20.746	22 56 24.254	10 42 55.000	...	+12 02 16.884	22 45 11.884	11 12.374	
	23 06 42.000	—1 20.742	23 05 21.258	10 51 50.500	...	+12 02 18.327	22 54 08.827	11 12.431	
								11 12.411	11 12.426
Sept. 24, Allegan	21 59 33.743	—1 20.486	21 58 13.257	...	21 54 53.000	— 7 52.307	21 47 00.693	11 12.564	
	22 00 34.219	—1 20.486	21 59 13.733	...	21 55 53.500	— 7 52.312	21 48 01.188	11 12.545	
	22 15 18.156	—1 20.487	22 13 57.669	...	22 10 37.500	— 7 52.380	22 02 45.120	11 12.549	
	22 18 33.172	—1 20.487	22 17 12.685	...	22 13 52.500	— 7 52.395	22 06 00.105	11 12.580	
								11 12.560	
Sept. 24, Detroit	22 08 06.000	—1 20.487	22 06 45.513	9 49 30.500	...	+12 06 02.577	21 55 33.077	11 12.436	
	22 23 25.000	—1 20.488	22 22 04.512	10 04 47.000	...	+12 06 05.025	22 10 52.025	11 12.487	
	22 26 29.000	—1 20.488	22 25 08.512	10 07 50.500	...	+12 06 05.517	22 13 56.017	11 12.495	
								11 12.473	11 12.516
September 23, mean of signals, both directions									11 12.426
September 24, mean of signals, both directions									11 12.516
Mean both nights									11 12.471
Relative personal equation									— .126
Allegan west of Detroit									11 12.345

Telegraphic longitude—1875.

DETROIT—NEWAYGO.

Signals sent from—	Detroit.			Newaygo.				Difference.	Mean both directions.
	Detroit clock.	Correction.	Sidereal time.	Mean solar chronometer.	Sidereal chronometer.	Correction.	Sidereal time.		
	h. m. s.	*m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*m. s.*	*m. s.*
Newaygo, Nov. 8	23 43 01.285	—1 18.756	23 41 42.529	....	23 39 22.500	— 8 40.209	23 30 42.291	11 00.238	
	23 44 01.287	—1 18.755	23 42 42.532	....	23 40 22.500	— 8 40.211	23 31 42.289	11 00.243	
	23 57 01.216	—1 18.741	23 55 42.475	....	23 53 22.500	— 8 40.234	23 44 42.266	11 00.209	
	23 58 01.225	—1 18.740	23 56 42.485	....	23 54 22.500	— 8 40.236	23 45 42.264	11 00.221	
								11 00.228	
Detroit, Nov. 8	23 48 37.000	—1 18.750	23 47 18.250	10 35 23.500	....	+13 00 54.594	23 36 18.094	11 00.156	
	23 51 41.000	—1 18.746	23 50 22.254	10 38 27.000	....	+13 00 55.094	23 39 22.094	11 00.160	
	00 00 49.000	—1 18.737	23 59 30.263	10 47 33.500	....	+13 00 56.584	23 48 30.084	11 00.179	
	00 03 51.000	—1 18.734	00 02 32.266	10 50 35.000	....	+13 00 57.079	23 51 32.079	11 00.187	
	00 06 53.000	—1 18.731	00 05 34.269	10 53 36.500	....	+13 00 57.575	23 54 34.075	11 00.194	
								11 00.175	11 00.202
Newaygo, Nov. 18	23 27 07.003	—1 15.043	23 25 51.960	....	23 24 07.500	— 9 15.632	23 14 51.868	11 00.092	
	23 28 06.990	—1 15.043	23 26 51.947	....	23 25 07.500	— 9 15.635	23 15 51.865	11 00.082	
	23 38 21.953	—1 15.043	23 37 06.910	....	23 35 22.500	— 9 15.667	23 26 06.833	11 00.077	
	23 39 21.940	—1 15.044	23 38 06.896	....	23 36 22.500	— 9 15.670	23 27 06.830	11 00.066	
								11 00.079	
Detroit, Nov. 18	23 29 52.000	—1 15.043	23 28 36.957	9 37 38.500	....	+13 39 58.361	23 17 36.861	11 00.096	
	23 32 54.000	—1 15.043	23 31 38.957	9 40 40.000	....	+13 39 58.860	23 20 38.860	11 00.097	
	23 35 58.000	—1 15.043	23 34 42.957	9 43 43.500	....	+13 39 59.366	23 23 42.866	11 00.091	
	23 42 36.000	—1 15.044	23 41 20.956	9 50 20.500	....	+13 40 00.459	23 30 20.959	10 59.997	
								11 00.070	11 00.075

	m. s.
November 8, mean of signals, both directions	11 00.202
November 18, mean of signals, both directions	11 00.075
Mean both nights	11 00.138
Relative personal equation	— .126
Newaygo west of Detroit	11 00.012

EXPLANATION OF TABLES

Giving results for relative personal equation with A. R. Flint, and difference of longitude between Detroit, Tonawanda, and Mannsville.

There are three tables for relative personal equation, and for each station.

The first table gives the results found by comparisons of time-pieces recorded on Detroit clock-chronograph.

The second table gives the results found by comparisons of time-pieces recorded on Assistant Engineer Flint's chronograph.

The third table gives a summary from combination of results in both directions.

TABLES I AND II.

First column gives date of work.

Second column, Detroit clock-times of comparisons.

Third column, Flint's chronómeter-times of comparisons.

Fourth column, error of clock and epoch at which determined.

Fifth column, rate of clock for clock-hour.

Sixth column, error of chronometer and epoch at which determined.

Seventh column, rate of chronometer per chronometer-hour.

Eighth column, local sidereal time of comparisons as determined at Detroit.

Ninth column, local sidereal time of comparisons as determined at field-station.

Tenth column, individual results from comparisons.

Eleventh column, mean of individual comparisons for each night.

TABLE III.

First column gives date of work.

Second column gives mean difference of local sidereal time of comparisons of signals for each night from Detroit clock-chrongraph.

Third column, same for A. R. Flint's chronograph.

Fourth column, mean of both stations.

Fifth column, double repeater, armature, and wave time.

No. 1.

Telegraphic longitude—1875.

RELATIVE PERSONAL EQUATION—LIEUTENANT LOCKWOOD AND A. R. FLINT.

COMPARISON OF TIME-PIECES FROM LIEUTENANT LOCKWOOD'S CHRONOGRAPH.

Date.	Detroit clock-time of comparison.	Flint's chronometer-time of comparison.	Error of Detroit clock.	Rate per hour.	Error of Flint's chronometer.	Rate per hour.	Local sidereal time by Detroit clock.	Local sidereal time by Flint's chronometer.	Difference of times.	Mean each night.
	h. m. s.	*h. m. s.*	*m. s.*	*s.*	*m. s.*	*s.*	*h. m. s.*	*h. m. s.*	*s.*	*s.*
August 30, 1875	21 44 53.336	21 58 19.000	—1 20.630 at 22*h.*	—0.0255	—14 46.456 at 21*h.* 50*m.*	+0.091	21 43 32.696	21 43 32.557	+0.139	+0.139
August 31, 1875	21 46 36.197	22 00 00.000	—1 20.777 at 22*h.*	0.002	14 44.811 at 21*h.* 50*m.*	+0.086	21 45 15.420	21 45 15.203	+0.217	
	21 47 36.199	22 01 00.000					21 46 15.420	21 46 15.205	+0.215	
	21 56 36.195	22 10 00.000					21 55 15.418	21 55 15.218	+0.200	
	21 57 36.197	22 11 00.000					21 56 15.420	21 56 15.219	+0.201	+0.208
December 22, 1875	2 42 49.751	2 41 00.000	—0 55.155 at 3*h.*	+0.007	+ 0 54.461 at 2*h.* 40*m.*	+0.010	2 41 54.594	2 41 54.461	+0.133	
	2 43 49.756	2 42 00.000					2 42 54.599	2 42 54.461	+0.138	
	2 49 49.755	2 48 00.000					2 48 54.619	2 48 54.462	+0.157	
	2 50 49.781	2 49 00.000					2 49 54.625	2 49 54.462	+0.163	+0.148
December 27, 1875	2 49 13.775	2 46 00.000	—0 55.504 at 3*h.*	—0.0014	+ 2 18.067 at 2*h.* 50*m.*	+0.056	2 48 18.271	2 48 18.063	+0.208	
	2 50 13.773	2 47 00.000					2 49 18.269	2 49 18.064	+0.205	
	2 53 13.789	2 50 00.000					2 52 18.285	2 52 18.067	+0.218	
	2 54 13.794	2 51 00.000					2 53 18.290	2 53 18.068	+0.222	+0.213

No. 2.

Telegraphic longitude—1875.

RELATIVE PERSONAL EQUATION—LIEUTENANT LOCKWOOD AND A. R. FLINT.

COMPARISON OF TIME-PIECES FROM A. R. FLINT'S CHRONOGRAPH.

Date.	Detroit clock-time of comparison.	Flint's chronometer-time of comparison.	Error of Detroit clock.	Rate per hour.	Error of Flint's chronometer.	Rate per hour.	Local sidereal time by clock.	Local sidereal time by chronometer.	Difference of time.	Mean each night.
	h. m. s.	*h. m. s.*	*m. s.*	*s.*	*m. s.*	*s.*	*h. m. s.*	*h. m. s.*	*s.*	*s.*
August 30, 1875	21 37 00.000	21 50 25.755	−1 20.630 at 22*h*.	−0.0255	−14 46.456 at 21*h*. 50*m*.	+ 0.091	21 35 39.380	21 35 39.299	+ 0.081	+ 0.081
August 31, 1875	21 54 00.000	22 07 23.903	−1 20.777 at 22*h*.	−0.002	−14 44.811 at 21*h*. 50*m*.	+ 0.086	21 52 39.223	21 52 39.117	+ 0.106	
	21 55 00.000	22 08 23.902	....	....	....	....	21 53 39.223	21 53 39.117	+ 0.106	+ 0.106
December 22, 1875	2 39 00.000	2 37 10.304	−0 55.155 at 3*h*.	+0.007	+ 0 54.461 at 2*h*. 40*m*.	+ 0.010	2 38 04.847	2 38 04.765	+ 0.082	
	2 40 00.000	2 38 10.304	....	....	....	....	2 39 04.847	2 39 04.765	+ 0.082	
	2 46 00.000	2 44 10.300	....	....	....	....	2 45 04.847	2 45 04.762	+ 0.085	
	2 47 00.000	2 45 10.300	....	....	....	....	2 46 04.847	2 46 04.762	+ 0.085	+ 0.084
December 27, 1875	2 48 00.000	2 44 46.299	−0 55.504 at 3*h*.	−0.0014	+ 2 18.067 at 2*h*. 50*m*.	+ 0.056	2 47 04.496	2 47 04.361	+ 0.135	
	2 49 00.000	2 45 46.300	....	....	....	....	2 48 04.496	2 48 04.363	+ 0.133	
	2 52 00.000	2 48 46.284	....	....	....	....	2 51 04.496	2 51 04.350	+ 0.146	
	2 53 00.000	2 49 46.286	....	....	....	....	2 52 04.496	2 52 04.353	+ 0.143	+ 0.139

No. 3.

Telegraphic longitude—1875.

RELATIVE PERSONAL EQUATION—LIEUTENANT LOCKWOOD AND A. R. FLINT.

COMBINATION OF RESULTS FROM SIGNALS IN EACH DIRECTION.

Date.	Mean difference of local sidereal times determined from comparison of signals on Lieutenant Lockwood's chronograph.	Mean difference of local sidereal times determined from comparison of signals on Flint's chronograph.	Mean both directions.	Remarks.
	s.	s.	s.	
Aug. 30, 1875	+0.139	+0.081	+0.110	Assistant Engineer A. R. Flint observes later than Lieutenant Lockwood; and as he occupies stations during the season to the east of Lieutenant Lockwood, the value 0s.136 of relative personal equation must be added to observed differences of longitude in that direction.
Aug. 31, 1875	+0.208	+0.106	+0.157	
Dec. 22, 1875	+0.148	+0.084	+0.116	
Dec. 27, 1875	+0.213	+0.139	+0.176	
Mean of all			+0.140	

	s.
Mean of all	+0.140
Difference of time between piers	—0.004
Relative personal equation	0.136

No. 1.

Telegraphic longitude—1875.

DETROIT AND TONAWANDA, N. Y.

COMPARISON BY SIGNALS ON DETROIT CHRONOGRAPH, D. W. L.

Date.	Detroit clock-time of comparison.	Tonawanda chronometer-time of comparison.	Error of Detroit clock.	Rate per hour.	Error of Tonawanda chronometer.	Rate per hour.	Local sidereal time at Detroit.	Local sidereal time at Tonawanda.	Difference.	Means each night.
	h. m. s.	*h. m. s.*	*m. s.*	*s.*	*m. s.*	*s.*	*h. m. s.*	*h. m. s.*	*m. s.*	*m. s.*
Sept. 23, 1875	21 49 17.910	22 02 00.000	−1 20.769 at 22*h.*	+0.0243	+2 35.832 at 22*h.*	+0.054	21 47 57.137	22 04 35.834	16 38.697	
	21 50 17.910	22 03 00.000	....	....	....	....	21 48 57.137	22 05 35.835	38.698	
	21 51 17.900	22 04 00.000	....	....	....	....	21 49 57.128	22 06 35.836	38.708	
	21 56 17.910	22 09 00.000	....	....	....	....	21 54 57.140	22 11 35.840	38.700	
	21 57 17.910	22 10 00.000	....	....	....	....	21 55 57.140	22 12 35.841	38.701	
	21 58 17.900	22 11 00.000	....	....	....	....	21 56 57.130	22 13 35.842	38.712	16 38.703
Sept. 24, 1875	21 35 19.484	21 48 00.000	−1 20.486 at 22*h.*	−0.004	+2 37.678 at 22*h.*	+0.075	21 33 59.000	21 50 37.663	16 38.663	
	21 37 19.489	21 50 00.000	....	....	....	....	21 35 59.005	21 52 37.666	38.661	
	21 42 19.493	21 55 00.000	....	....	....	....	21 40 59.008	21 57 37.672	38.663	
	21 44 19.495	21 57 00.000	....	....	....	....	21 42 59.010	21 59 37.674	38.664	16 38.663
Oct. 2, 1875	23 11 25.803	23 23 50.000	−1 19.718 at 0*h.*	+0.0097	+2 54.758 at 23*h.* 30*m.*	+0.176	23 10 06.077	23 26 44.740	16 38.663	
	23 13 25.803	23 25 50.000	....	....	....	....	23 12 06.078	23 28 44.746	38.668	
	23 19 25.829	23 31 50.000	....	....	....	....	23 18 06.105	23 34 44.763	38.658	
	23 20 25.830	23 32 50.000	....	....	....	....	23 19 06.106	23 35 44.766	38.660	16 38.662
Oct. 8, 1875	23 15 48.235	23 28 00.000	−1 18.738 at 0*h.*	+0.0621	+3 08.145 at 23*h.* 30*m.*	+0.111	23 14 29.451	23 31 08.141	16 38.690	
	23 16 48.240	23 29 00.000	....	....	....	....	23 15 29.458	23 32 08.143	38.685	
	23 23 48.246	23 36 00.000	....	....	....	....	23 22 29.471	23 39 08.156	38.685	
	23 24 48.245	23 37 00.000	....	....	....	....	23 23 29.471	23 40 08.158	38.687	16 38.687
Oct. 13, 1875	23 13 03.000	23 25 00.000	−1 16.920 at 0*h.*	+0.036	+3 24.743 at 23*h.* 30*m.*	+0.151	23 11 46.052	23 28 24.730	16 38.678	
	23 15 03.000	23 27 00.000	....	....	....	....	23 13 46.053	23 30 24.735	38.682	
	23 21 03.000	23 33 00.000	....	....	....	....	23 19 46.057	23 36 24.751	38.694	
	23 22 03.000	23 34 00.000	....	....	....	....	23 20 46.057	23 37 24.753	38.696	16 38.687

No. 2.

Telegraphic longitude—1875.

DETROIT AND TONAWANDA, N. Y.

COMPARISON BY SIGNALS ON TONAWANDA CHRONOGRAPH, A. R. F.

Date.	Detroit clock-time of comparison.	Tonawanda chronometer-time of comparison.	Error of Detroit clock.	Rate per hour.	Error of Tonawanda chronometer.	Rate per hour.	Local sidereal time at Detroit.	Local sidereal time at Tonawanda.	Difference.	Mean each night.
	h. m. s.	*h. m. s.*	*m. s.*	*s.*	*m. s.*	*s.*	*h. m. s.*	*h. m. s.*	*m. s.*	*m. s.*
Sept. 23, 1875	21 46 30.000	21 59 12.187	—1 20.769 at 22*h.*	+0.024	+2 35.832 at 22*h.*	+0.054	21 45 09.226	22 01 48.019	16 38.793	
	21 47 30.000	22 00 12.185	....	....	....	....	21 46 09.226	22 02 48.017	38.791	
	21 53 30.000	22 06 12.180	....	....	....	....	21 52 09.228	22 08 48.018	38.790	
	21 54 30.000	22 07 12.176	....	....	....	....	21 53 09.229	22 09 48.015	38.786	16 38.790
Sept. 24, 1875	21 32 30.000	21 45 10.605	—1 20.486 at 22*h.*	—0.004	+2 37.678 at 22*h.*	+0.075	21 31 09.516	21 47 48.264	16 38.748	
	21 33 30.000	21 46 10.602	....	....	....	....	21 32 09.516	21 48 48.263	38.747	
	21 39 30.000	21 52 10.606	....	....	....	....	21 38 09 515	21 54 48.274	38.759	
	21 40 30.000	21 53 10.604	....	....	....	....	21 39 09.515	21 55 48.273	38.758	16 38.753
Oct. 2, 1875	23 08 30.000	23 20 54.272	—1 19.718 at 0*h.*	+0.0097	+2 54.758 at 23*h.* 30*m.*	+0.176	23 07 10.274	23 23 49.002	16 38.728	
	23 09 30.000	23 21 54.270	....	....	....	....	23 08 10.274	23 24 49.003	38.729	
	23 15 30.000	23 27 54.243	....	....	....	....	23 14 10.275	23 30 48.993	38.718	
	23 16 30.000	23 28 54.240	....	....	....	....	23 15 10.275	23 31 48.995	38.720	16 38.724
Oct. 8, 1875	23 12 30.000	23 24 41.875	—1 18.738 at 0*h.*	+0.0621	+3 08.145 at 23*h.* 30*m.*	+0.111	23 11 11.213	23 27 50.020	16 38.807	
	23 13 30.000	23 25 41.885	....	....	....	....	23 12 11.214	23 28 50.022	38.808	
	23 20 30.000	23 32 41.862	....	....	....	....	23 19 11.221	23 35 50.012	38.791	
	23 21 30.000	23 33 41.865	....	....	....	....	23 20 11.222	23 36 50.017	38.795	16 38.800
Oct. 13, 1875	23 10 30.000	23 22 27.067	—1 16.920 at 0*h.*	+0.036	+3 24.743 at 23*h.* 30*m.*	+0.151	23 09 13.050	23 25 51.791	16 38.741	
	23 11 30.000	23 23 27.065	....	....	....	....	23 10 13.051	23 26 51.792	38.741	
	23 17 30.000	23 29 27.048	....	....	....	....	23 16 13.053	23 32 51.789	38.736	
	23 18 30.000	23 30 27.047	....	....	....	....	23 17 13.055	23 33 51.791	38.736	16 38.738

No. 3.

Telegraphic longitude—1875.

DETROIT AND TONAWANDA.

COMBINATION OF RESULTS FROM SIGNALS IN BOTH DIRECTIONS.

Date.	Mean difference of local sidereal times from comparison of signals on Detroit clock-chronograph D. W. L.	Mean difference of local sidereal times from comparison of signals on Tonawanda chronograph A. R. F.	Mean both directions.	Double repeater, wave, and armature time.	Remarks.
1875.	*m.* *s.*	*m.* *s.*	*m.* *s.*	*s.*	
Sept. 23	16 38.703	16 38.790	16 38.747	0.087	The telegraph line used was via Buffalo, through Canada. One repeater at Buffalo.
Sept. 24	16 38.663	16 38.753	16 38.708	0.090	
Oct. 2	16 38.662	16 38.724	16 38.693	0.062	
Oct. 8	16 38.687	16 38.800	16 38.743	0.113	
Oct. 13	16 38.687	16 38.738	16 38.713	0.051	
Mean of all			16 38.721		
Relative personal equation			+.136		
Difference of longitude			16 38.857		
Reduction of observing post to Δ			— 0.028		
Δ Tonawanda east of Detroit			16 38.829		

No. 1.

Telegraphic longitude—1875.

DETROIT AND MANNSVILLE.

COMPARISON BY SIGNALS ON DETROIT CHRONOGRAPH.

Date.	Detroit clock-time of comparisons.	Mannsville chronometer-time of comparison.	Error of Detroit clock.	Rate per hour.	Error of Mannsville chronometer.	Rate per hour.	Local sidereal time at Detroit.	Local sidereal time at Mannsville.	Difference.	Mean for each night.
1875.	h. m. s.	h. m. s.	m. s.	s.	m. s.	s.	h. m. s.	h. m. s.	m. s.	m. s.
Nov. 6	1 08 47.600	1 20 00.000	−1 08.661 at 1h. 30m.	−0.0088	+15 35.364 at 1h. 30m.	+0.092	1 07 38.942	1 35 35.349	27 56.407	
	1 09 47.600	1 21 00.000					1 08 38.942	1 36 35.350	56.408	
	1 10 47.600	1 22 00.000					1 09 38.942	1 37 35.352	56.410	
	1 11 47.600	1 23 00.000					1 10 38.942	1 38 35.353	56.411	
	1 15 47.600	1 27 00.000					1 14 38.941	1 42 35.359	56.418	
	1 16 47.600	1 28 00.000					1 15 38.941	1 43 35.361	56.420	
	1 17 47.600	1 29 00.000					1 16 38.941	1 44 35.363	56.422	
	1 18 47.600	1 30 00.000					1 17 38.941	1 45 35.364	56.423	27 56.415
Nov. 8	1 11 52.615	1 23 00.000	−1 07.653 at 1h. 30m.	+0.003	+15 41.451 at 1h. 30m.	+0.173	1 10 44.961	1 38 41.431	27 56.470	
	1 12 52.616	1 24 00.000					1 11 44.962	1 39 41.434	56.472	
	1 13 52.617	1 25 00.000					1 12 44.963	1 40 41.437	56.474	
	1 17 52.638	1 29 00.000					1 16 44.984	1 44 41.448	56.462	
	1 18 52.632	1 30 00.000					1 17 44.978	1 45 41.451	56.473	
	1 19 52.638	1 31 00.000					1 18 44.984	1 46 41.454	56.470	27 56.470
Nov. 11	1 25 02.201	1 36 00.000	−1 06.343 at 1h. 30m.	+0.0098	+15 52.384 at 1h. 30m.	+0.134	1 23 55.857	1 51 52.397	27.56.540	
	1 26 02.202	1 37 00.000					1 24 55.858	1 52 52.400	56.542	
	1 27 02.202	1 38 00.000					1 25 55.859	1 53 52.402	56.543	
	1 31 02.204	1 42 00.000					1 29 55.861	1 57 52.411	56.550	
	1 32 02.205	1 43 00.000					1 30 55.862	1 58 52.413	56.551	
	1 33 02.208	1 44 00.000					1 31 55.865	1 59 52.415	56.550	27 56.546
Nov. 12	1 17 04.788	1 28 00.000	−1 06.071 at 1h. 30m.	+0.0143	+15 55.250 at 1h. 30m.	+0.082	1 15 58.714	1 43 55.247	27 56.533	
	1 18 04.788	1 29 00.000					1 16 58.714	1 44 55.249	56.535	
	1 19 04.787	1 30 00.000					1 17 58.713	1 45 55.250	56.537	
	1 24 04.792	1 35 00.000					1 22 58.720	1 50 55.257	56.537	
	1 25 04.794	1 36 00.000					1 23 58.722	1 51 55.258	56.536	
	1 26 04.794	1 37 00.000					1 24 58.722	1 52 55.260	56.538	
	1 34 04.798	1 40 00.000					1 32 58.728	1 55 55.264	56.536	
	1 35 04.798	1 41 00 000					1 33 58.728	1 56 55.265	56.537	
	1 36 04.799	1 42 00.000					1 34 58.729	1 57 55.266	56.537	27 56.536

No. 2.

Telegraphic longitude—1875.

DETROIT AND MANNSVILLE, N. Y.

COMPARISON BY SIGNALS ON MANNSVILLE CHRONOGRAPH.

Date.	Detroit clock-time of comparison.	Mannsville chronometer-time of compairson.	Error of Detroit clock.	Rate per hour.	Error of Mannsville chronometer.	Rate per hour.	Local sidereal time at Detroit.	Local sidereal time at Mannsville.	Difference.	Mean for each night.
	h. m. s.	*h. m. s.*	*m. s.*	*s.*	*m. s.*	*s.*	*h. m. s.*	*h. m. s.*	*m. s.*	*m. s.*
Nov. 6, 1875	1 06 30.000	1 17 42.575	−1 08.661 at 1*h.* 30*m.*	−0.0088	+15 35.364 at 1*h.* 30*m.*	+0.092	1 05 21.342	1 33 17.920	27 56.578	
	1 07 33.000	1 18 45.555	....	....	....	....	1 06 24.342	1 34 20.902	56.560	
	1 13 30.000	1 24 42.555	....	....	....	....	1 12 21.341	1 40 17.911	56 570	
	1 14 33.000	1 25 45.584	....	....	....	....	1 13 24.341	1 41 20.941	56.600	27 56.577
Nov. 8, 1875	1 09 00.000	1 20 07.546	−1 07.653 at 1*h.* 30*m.*	+0.0034	+15 41.451 at 1*h.* 30*m.*	+0.173	1 07 52.346	1 35 48.968	27 56.622	
	1 16 00.000	1 27 07.564	....	....	....	....	1 14 52.346	1 42 49.007	56.661	
	1 23 00.000	1 34 07.544	....	....	....	....	1 21 52.347	1 49 49.007	56.660	
	1 29 30.000	1 40 37.494	....	....	....	....	1 28 22.347	1 56 18.976	56.629	27 56.643
Nov. 11, 1875	1 22 30.000	1 33 27.949	−1 06.343 at 1*h.* 30*m.*	+0.0098	+15 52.384 at 1*h.* 30*m.*	+0.134	1 21 23.656	1 49 20.341	27 56.685	
	1 23 25.000	1 34 22.952	....	....	....	....	1 22 18.656	1 50 15.346	56.690	
	1 29.00.000	1 39 57.941	....	....	....	....	1 27 53.657	1 55 50.347	56.690	
	1 30 00.000	1 40 57.964	....	....	....	....	1 28 53.657	1 56 50.373	56.716	27 56.695
Nov. 12, 1875	1 15 00.000	1 25 55.390	−1 06.071 at 1*h.* 30*m.*	+0.0143	+15 55.250 at 1*h.* 30*m.*	+0.082	1 13 53.925	1 41 50.634	27 56.709	
	1 16 00.000	1 26 55.398	....	....	....	....	1 14 53.926	1 42 50.644	56.718	
	1 21 00.000	1 31 55.350	....	....	....	....	1 19 53.927	1 47 50.602	56.675	
	1 22 00.000	1 32 55.387	....	....	....	....	1 20 53.927	1 48 50.641	56.714	27 56.704

No. 3.

Telegraphic longitude—1875.

DIFFERENCE OF LONGITUDE—DETROIT AND MANNSVILLE, N. Y.

COMBINATION OF RESULTS FROM SIGNALS IN BOTH DIRECTIONS.

Date.	Mean difference of local sidereal times from comparison of signals on Detroit clock-chronograph D. W. L.	Mean difference of local sidereal times from comparison of signals on Mannsville chronograph A. R. F.	Mean, both directions.	Double repeater, wave, and armature time.	Remarks.
1875.	m. s.	m. s.	m. s.	s.	
November 6	27 56. 415	27 56. 577	27 56. 496	0. 162	The telegraph-line used was through Canada, via Toronto and Kingston. At Toronto there was a repeater in the line.
November 8	27 56. 470	27 56. 643	27 56. 557	0. 173	
November 11	27 56. 546	27 56. 695	27 56. 620	0. 149	
November 12	27 56. 536	27 56. 704	27 56. 620	0. 168	
Mean			27 56. 573	......	
Relative personal equation			+. 136	......	
Difference of longitude			27 56. 709	......	
Reduction of observing post to △ Mannsville			+1. 748	......	
△ Mannsville east of Detroit			27 58. 457	......	

Respectfully submitted.

D. W. LOCKWOOD,
First Lieutenant of Engineers.

Maj. C. B. COMSTOCK, *Corps of Engineers, U. S. A.*

APPENDIX C.—ASTRONOMICAL WORK.

REPORT OF LIEUTENANT P. M. PRICE, CORPS OF ENGINEERS.

DETROIT, MICH., *June* 1, 1876.

MAJOR: I have the honor to submit the following report of my work during the past year:

I reported for duty on the Lake Survey on the 13th of May, 1875, and was assigned to astronomical work as field-observer, in connection with Lieutenant Lockwood, at Detroit; the observations being made for the purpose of determining the co-ordinates of points in the interior of Michigan.

For the determination of the personal equation between Lieutenant Lockwood and myself, observations were made at Detroit on three nights previous to starting into the field and on three nights after returning to Detroit.

I left Detroit on the 2d of July, and made observations for latitude and longitude at the following towns, which are the county-seats of their respective counties, viz: Charlotte, Eaton County; Marshall, Calhoun County; Kalamazoo, Kalamazoo County; Paw Paw, Van Buren County; and Stanton, Montcalm County; and returned to Detroit on the 26th of October.

Very unfavorable weather was experienced at each of the above places, with the exception of Kalamazoo, where four good nights for observation occurred within the first week.

The observing-piers were roughly-dressed sandstone posts, whose dimensions were 5 feet × 22 inches × 16 inches, which were sunk about 3¼ feet in the ground and left as permanent monuments.

A smoothly-dressed triangular top-stone, 1 foot in height, was placed upon the piers during the observations.

The piers at each station were connected by azimuths and distances with a section corner, one or more brick or stone buildings, and the intersections of the axis of several of the principal streets.

The following instruments were employed: Würdemann zenith-telescope, No. 12, 32 inches focal length; Würdemann transit, No. 15, 31.5 inches focal length; Negus break-circuit sidereal chronometer, No. 1541; and Hutton mean solar chronometer, No. 353.

The observations were made by the eye-and-ear method, the break-circuit chronometer being used in the time-determinations and in sending signals to Detroit.

The signals from Detroit were observed by the mean-time chronometer, at least four coincidences with the Detroit clock being obtained.

The mean-time chronometer was compared with the break-circuit sidereal chronometer by coincidences both before and after sending signals.

The programme of stars for time-work was arranged as indicated in Appendix B, Lake-Survey Report for 1874.

The time-work was reduced by the method of high and low stars.

During the winter I have been principally engaged in computing astronomical work.

I have also examined and made descriptions of the topographical maps of Great Britain, Switzerland, Prussia, Sweden, and Norway, and translated a paper from the Spanish geodetic surveys.

The time-computations were duplicated by Lieutenant Powell, and the individual and mean corrections of the chronometer and the adopted rates are given in the tables appended, in which Δt_0 represents the chronometer-correction at the epoch stated.

The latitude-computations have been duplicated by Assistant Engineers J. H. Darling and L. L. Wheeler, and the adopted latitudes are given below. The probable errors have been computed from the arithmetical mean.

The results for personal equation and differences of longitude will be found in the report of Lieutenant Lockwood.

On the 22d of May, 1876, I was ordered to take charge of the steamer Ada for hydrographic work in Lake Erie, and am now engaged in fitting her out for that purpose.

Very respectfully, your obedient servant,

PHILIP M. PRICE,
First Lieutenant of Engineers.

Maj. C. B. COMSTOCK,
Corps of Engineers.

Latitude.

Station.	Date.	Number of pairs.	Latitude.	Probable error.
	1875.		° ′ ″	″
Charlotte	July 7	17	42 34 04.42	
Do	July 9	25	03.65	
Do	July 10	30	04.36	
Mean		72	42 34 04.12	±0.10
Marshall	Aug. 8	28	42 16 21.04	
Do	Aug. 17	24	21.40	
Mean		52	42 16 21.21	±0.09
Kalamazoo	Sept. 3	25	42 17 26.03	
Do	Sept. 6	26	25.64	
Mean		51	42 17 25.83	±0.10
Paw Paw	Sept. 22	25	42 13 02.30	
Do	Sept. 27	29	02.51	
Mean		54	42 13 02.41	±0.13
Stanton	Oct. 21	29	43 17 29.84	
Do	Oct. 22	30	29.65	
Mean			43 17 29.74	±0.08

Individual and mean results for corrections of chronometer at Detroit and adopted rates.

Star.	June 3.	Star.	June. 18.	June. 19.	Star.	November 5.	November 11.	November 12.
	Δt_0 at 15h sidereal time.		Δt_0 at 17h.5 sidereal time.			Δt_0 at 2h.0 sidereal time.	Δt_0 at 2h.0 sidereal time.	Δt_0 at 2h.0 sidereal time.
	s.		*s.*	*s.*		*m.* *s.*	*m.* *s.*	*m.* *s.*
43 Comæ	— 31. 20	μ^1 Bootis	—29. 60	—28. 25	τ Pegasi	—4 — 37. 71	—4 — 16. 09	—4 — 12. 53
20 Canum Venaticorum	31. 20	β Coronæ	29. 46	28. 29	υ Pegasi	37. 77	16. 17	12. 58
α Virginis	31. 01	ν^1 Bootis	29. 53	28. 29	70 Pegasi	37. 88	16. 22	12. 50
ξ Virginis	30. 84	ζ^2 Coronæ	29. 56	28. 32	72 Pegasi	37. 72	16. 06	12. 67
τ Bootis	31. 12	γ Coronæ	29. 29	28. 31	ι Piscium	37. 77	15. 94	12. 66
τ Virginis	31. 11	ϵ Serpentis	29. 25	28. 10	ψ Pegasi	37. 62	16. 10	12. 60
d Bootis	31. 05	γ Serpentis	29. 36	28. 54	ω Piscium	37. 74	16. 06	12. 77
υ Virginis	31. 13	β^1 Scorpii	29. 62	28. 14	α Andromedæ	....	15. 89	12. 69
ϕ Virginis	31. 27	ξ Ophiuchi	29. 65	28. 54	γ Pegasi	37. 85	16. 00	12. 87
ρ Bootis	31. 14	ε Ophiuchi	29. 74	28. 50	ι Ceti	37. 95	16. 09	12. 75
π^1 Bootis	31. 08	γ Herculis	29. 58	28. 34	12 Ceti	37. 88	15. 98	12. 81
γ Herculis	31. 21	ξ Ophiuchi	29. 62	28. 12	π Andromedæ	....	16. 17	12. 83
ω Herculis	31. 19	ξ Herculis	29. 52	28. 15	ϵ Andromedæ	37. 89	15. 96	12. 63
λ Ophiuchi	31. 05	η Herculis	29. 75	28. 23	ξ Andromedæ	....	....	12. 77
ξ Ophiuchi	30. 95	49 Herculis	29. 74	28. 43	41 Arietis	37. 87	15. 98	12. 60
ξ Herculis	31. 09	ι Aquilæ	29. 75	28. 41	η Eridani	37. 82	15. 98	12. 61
49 Herculis	31. 08	110 Herculis	29. 39	28. 04	α Ceti	37. 67	15. 83	12. 63
ε Herculis	30. 94	β Lyræ	29. 57	28. 43	β Persei	37. 76	15. 92	12. 53
60 Herculis	31. 26	θ^1 Serpentis	29. 46	28. 32	δ Arietis	....	15. 90	12. 61
Gr. 2415	31. 22	ε Aquilæ	29. 53	28. 32	ζ Arietis	....	15. 99	12. 61
α^1 Herculis	31. 07	ξ Aquilæ	....	28. 46	o Tauri	37. 88	16. 04	12. 70
α Ophiuchi	31. 32	ι Lyræ	29. 54	28. 30	ξ Tauri	....	16. 30	12. 90
β Ophiuchi	30. 90	ω Aquilæ	29. 59	28. 28	f Tauri	....	16. 07	12. 75
		δ Aquilæ	29. 66	28. 34	ϵ Eridani	....	16 14	12. 86
		β Cygni	29. 40	28. 11	θ Persei	....	16. 27	12. 81
		κ Aquilæ	29 65	28. 34	η Tauri	....	16. 25	....
Mean	— 31. 106	Mean	— 29. 551	— 28. 304	Mean	—4 — 37. 794	—4 — 16. 053	—4 — 12. 690
Hourly rate	— 0. 001	Hourly rate	— 0. 012	— 0. 018	Hourly rate	+ 0. 111	+ 0. 066	+ 0. 063

Individual and mean results for corrections of chronometer at Charlotte, Mich., and adopted rates.

Star.	July 20. Δt_0 at 19h.0 chronometer-time.	Star.	July 24. Δt_0 at 20h.5 chronometer-time.
	m. *s.*		*m.* *s.*
ε Ophiuchi	—7 —08.60	1 Aquilæ	—7 —02.40
γ Herculis	08.63	α Lyræ	02.02
ζ Ophiuchi	08.67	110 Herculis	02.12
ζ Herculis	08.64	β Lyræ	02.28
η Herculis	08.57	θ¹ Serpentis	02.45
49 Herculis	08.81	ε Aquilæ	02.35
κ Ophiuchi	08.78	ζ Aquilæ	02.24
ε Herculis	08.60	1 Lyræ	02.10
α¹ Herculis	08.66	ω Aquilæ	02.18
π Herculis	08.60	δ Aquilæ	02.20
α Ophiuchi	08.91	β Cygni	02.10
β Ophiuchi	08.75	κ Aquilæ	02.07
γ Ophiuchi	08.82	ε Pegasi	02.14
θ Herculis	08.78	μ Capricorni	02.33
67 Ophiuchi	08.64	20 Pegasi	02.33
72 Ophiuchi	08.78	α Aquarii	02.33
α² Capricorni	08.71	θ Pegasi	02.31
γ Cygni	08.59	θ Aquarii	02.24
π Capricorni	08.68	γ Aquarii	02.05
ε Delphini	08.77	π Aquarii	02.02
α Delphini	08.71	λ Pegasi	02.14
γ² Delphini	08.72	μ Pegasi	02.15
μ Aquarii	08.69		
ν Cygni	08.74		
Mean	—7 —08.701	Mean	—7 —02.208
Hourly rate	— 0.022	Hourly rates	— 0.038

Individual and mean results for corrections of chronometer at Marshall, Mich., and adopted rates.

Star.	August 13. Δt_0 at 20h.0 chronometer-time.	August 24. Δt_0 at 20h.5 chronometer-time.
	m. *s.*	*m.* *s.*
1 Aquilæ	—7 —15.23	—7 —01.99
α¹ Lyræ	15.37	01.66
110 Herculis	15.34	01.82
β Lyræ	15.45	02.08
θ¹ Serpentis	15.62	02.25
ε Aquilæ	15.48	02.16
ζ Aquilæ	15.66	02.19
ν Lyræ	15.37	01.77
ω Aquilæ	15.44	02.16
δ Aquilæ	15.77	02.08
β Cygni	15.51	01.96
κ Aquilæ	15.79	02.04
ε Pegasi	15.47	....
μ Capricorni	15.33	01.96
20 Pegasi	15.43	01.90
α Aquarii	15.63	02.04
θ Pegasi	15.36	02.13
θ Aquarii	15.50	02.03
γ Aquarii	15.57	02.10
π Aquarii	15.50	01.91
η Aquarii	15.57	02.12
ζ Pegasi	15.69	01.99
λ Pegasi	15.44	01.97
μ Pegasi	15.56	01.99
Mean	— 7 — 15.503	—7 —02.013
Hourly rate	— 0.019	+ 0.045

Individual and mean results for corrections of chronometer at Kalamazoo, Mich., and adopted rates.

Star.	August 30. Δt_0 at 22h.0 chronometer-time.	August 31. Δt_0 at 22h.2 chronometer-time.
	m. s.	m. s.
α^2 Capricorni	—9 —28. 19	—10 —47. 95
γ Cygni	27. 85	47. 85
π Capricorni	27. 98	47. 84
ε Delphini	28. 24	47. 94
α Delphini	28. 32	47. 65
δ Delphini	28. 41	47. 85
γ^2 Delphini	28. 46	47. 98
ν Cygni	28. 30	47. 59
61[1] Cygni	28. 14	47. 51
ζ Cygni	28. 35	47. 85
τ Pegasi	28. 03	....
υ Pegasi	28. 19	47. 61
θ Piscium	28. 26	47. 76
72 Pegasi	28. 31	48. 01
ι Andromedæ	28. 27	....
ι Piscium	....	47. 75
ψ Pegasi	28. 28	47. 90
ω Piscium	28. 21	47. 96
α Andromedæ	28. 23	47. 90
γ Pegasi	28. 13	47. 61
ι Ceti	28. 35	47. 74
12 Ceti	....	47. 72
Mean	—9 —28. 225	—10 —47. 798
Hourly rate	+ 0. 024	+ 0. 003

Individual and mean results for corrections of chronometer at Paw Paw, Mich., and adopted rates.

Star.	September 23. Δt_0 at 22h.2 chronometer-time.	September 24. Δt_0 at 22h.2 chronometer-time.
	m. s.	m. s.
α^2 Capricorni	—11 —11. 48	—11 —09. 62
γ Cygni	11. 26	09. 23
π Capricorni	11. 47	09. 60
ϵ Delphini	11. 43	09. 53
α Delphini	11. 34	09. 39
δ Delphini	11. 54	09. 40
γ^2 Delphini	11. 54	09. 60
ν Cygni	11. 42	09. 30
61[1] Cygni	11. 42	09. 22
ζ Cygni	11. 54	09 40
ψ Pegasi	....	09. 64
ω Piscium	11. 57	09. 45
α Andromedæ	11. 44	09. 41
γ Pegasi	11. 43	09. 28
ι Ceti	11. 36	09. 39
12 Ceti	11. 40	....
Mean	—11 —11. 442	—11 —09. 429
Hourly rate	+ 0. 099	+ 0. 032

Individual and mean results for corrections of chronometer at Stanton, Mich., and adopted rates.

Star.	October 13. Δt_0 at $0^h.7$ chronometer-time.	October 20. Δt_0 at $0^h.15$ chronometer-time.
	m. s.	m. s.
ξ Aquarii	—9 —47.02	—9 —19.85
ε Pegasi	47.14	19.54
μ Capricorni	47.11	19.83
20 Pegasi	47.01	19.68
α Aquarii	47.12	19.81
θ Pegasi	46.95	19.88
θ Aquarii	47.02	19.81
γ Aquarii	46.92	19.98
π Aquarii	47.19	19.98
η Aquarii	47.13	20.00
ξ Pegasi	47.17	19.84
λ Pegasi	46.97	20.00
μ Pegasi	46.88	20.00
β Arietis	47.14	19.92
γ Andromedæ	47.22	19.97
α Arietis	47.01	19.89
ξ¹ Ceti	47.02	19.92
γ Trianguli	47.01	19.99
ξ² Ceti	46.98	19.96
ν Arietis	47.02	....
γ Ceti	47.01	19.74
41 Arietis	47.03	19.77
η Eridani	47.15	19.75
α Ceti	46.91	19.72
Mean	—9 —47.047	—9 —19.861
Hourly rate	+ 0.121	+ 0.046

Geographical positions.

Station.	Points.	Latitude.	Longitude west from Greenwich.
		° ′ ″	° ′ ″
Charlotte, Eaton County, Mich.	Astronomical post	42 34 04.12	84 50 01.46
	Intersection of axis of Oliver and Stoddard streets	33 58.96	01.21
	Intersection of axis of Oliver street and Harris avenue.	33 53.19	01.15
	Intersection of axis of Harris and Cochran avenues	33 53 12	10.02
	Northwest corner of Sherwood House	33 49.13	09.34
	Northwest corner of jail	33 52.45	13.90
	Northeast corner of section 13, township 2 north, range 5 west.	34 04.31	10.09
Marshall, Calhoun County, Mich.	Astronomical post	42 16 21.21	84 57 49.11
	Northwest corner of section 25, township 2 south, range 6 west.	27.65	49.20
	Intersection of axis of Kalamazoo avenue and Mansion street.	24.67	49.16
	Intersection of axis of Kalamazoo avenue and Green street.	17.76	49.06
	Intersection of axis of State and Sycamore streets	21.17	54.28
	Intersection of axis of State and Grand streets	21.25	43.93
	Northwest corner of court-house	16.72	46.95
	Northeast corner of third ward school-house	18.95	50.10
Kalamazoo, Kalamazoo County, Mich.	Astronomical post	42 17 25.83	85 35 05.60
	Southwest corner of jail	28.37	05.67
	Intersection of axis of South and Church streets	24.55	07.27
	Intersection of axis of Church and Lovell streets	20.97	07.11
	Intersection of axis of Park and South streets	23.46	11.79
	Southwest corner of section 15, township 2 south, range 11 west.	21.01	20.13
	Intersection of axis of Lovell and Park streets	20.98	11.67
Paw Paw, Van Buren County, Mich.	Astronomical post	42 13 02.41	85 53 04.94
	Intersection of axis of Main and Van Buren streets	01.66	03.35
	Southwest corner of public school-house	02.16	00.70
	Southwest corner of section 7, township 3 south, range 13 west.	12 55.00	52 40.44
Stanton, Montcalm County, Mich.	Astronomical post	43 17 29.74	85 04 58.80
	Southwest corner of section 31, township 11 north, range 6 west.	30.73	05 03.24
	Northwest corner of county record office	28.95	04 58.36
	Intersection of axes of Main and Camburn streets	30.67	52.46
	Northwest corner of brick building on southeast corner of Main and Camburn streets.	30.12	52.03

APPENDIX D.—ASTRONOMICAL WORK.

REPORT OF LIEUTENANT THOMAS N. BAILEY, CORPS OF ENGINEERS.

OFFICE UNITED STATES LAKE SURVEY,
Detroit, Mich., May 1, 1876.

MAJOR: I have the honor to submit the following report of my work for the past year:

By office-letter of May 10, 1875, I was assigned as field-observer, in connection with Lieutenant Lockwood, at Detroit, to determine the geographical positions of several points in Michigan.

After observing for relative personal equation, I left Detroit May 27, and occupied, in succession, Howell, Lansing, Hastings, Jackson, Allegan, and Newaygo; returning to Detroit October 23, when personal equation was again determined.

The instrument used for both time and latitude observations was Pistor and Martin's transit No. 2, 24.5 inches focal length. This being a new instrument, the determination of all its constants was necessary. I have previously reported the results.

At each station, the transit was mounted upon a well-settled stone post, placed upon public ground when convenient, and allowed to remain in position, being connected with United States land survey and local objects of permanency. Meridian-marks were given, upon request, at several stations.

In time-observations, a sidereal chronometer was used, the eye-and-ear method being followed.

For sending telegraphic signals to Detroit, a break-circuit sidereal chronometer was employed the first part of the season, and afterward, as this chronometer was, according to instructions, shipped to Detroit, signals were sent by hand-breaks; they were received in the field by a mean-time chronometer, using coincidences.

By office letter of August 24, 1875, I was instructed to investigate, upon my return from the field, the question, "whether your break-circuit chronometer's chronograph-record is simultaneous with its tick." The best method of observation that occurred to me was to compare by coincidence the sidereal chronometer's tick and relay-break alternately with the tick of a mean solar chronometer. Then for each mean solar chronometer-time of coincidence there corresponded an observed sidereal time by ticks (or breaks) and a time, computed from the next coincidence, by breaks (or ticks.) The time by breaks, subtracted from the time by ticks, gave one resulting difference. The mean of 16 such results was $= -0^s.005$, being less than the error of observation.

The instrument I used in time-work being a "broken" transit, or one with the eye-piece at the end of a trunnion, I was instructed to examine personal equation resulting from observing a time-star apparently passing in one direction (lamp east) with a passage in the opposite direction (lamp west.) The following is the result:

Let R = a single result for error of chronometer with all corrections but personal equation applied.
A = mean of all *R*'s for a night;
E = mean of all *R*'s for same night with lamp east;
W = mean of all *R*'s for same night with lamp west.

The mean of the value of $W - E$ for 20 nights was $+ 0^s.026 \pm 0^s.018$. The result being so small compared with its probable error, further examination was abandoned.

With this instrument, the full turns of micrometer are indicated on a scale placed just above the eye-piece, the bar *a, b*, with index moving along the plate *c, d*. (See figure on next page.) The divisions of this scale are so small, that a magnifying-glass and a strong light held in an inconvenient position are necessary to read it. Finding that the effect on the eye was very fatiguing, I designed an attachment for enlarging the scale.

It consists of a pointer, *p*, pivoted at *m*, and working through a small pin at *n*; the bearings are steel points in brass, with just sufficient pressure from the springs *s*, to keep them in place.

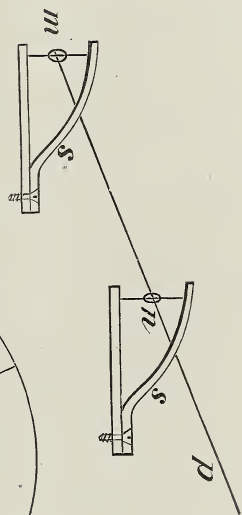
The transit being furnished with two equally sensitive setting (latitude) levels, I suggested, and, by your permission, made use of both of these levels in latitude work, increasing as much as 85 per cent. the number of stars observed per hour as compared with zenith-telescope work.

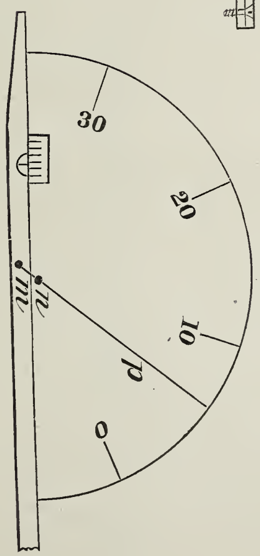
The method is as follows: Suppose four stars in this order of right ascension: A_n, B_n, A_s, B_s; A_n and A_s forming a pair and B_n and B_s another pair. Set level A for the pair A_n, A_s; and level B for the pair B_n, B_s; observe the star A_n reading micrometer and level A; then as the relation of level A to line of collimation will not be changed, the telescope and levels may be moved together in altitude to observe the star B_n, recording micrometer and level B; turn the instrument 180° in azimuth and observe similarly A_s and B_s, when all data for the two separate pairs will be obtained.

Level A may be reset for a third pair after the star A_s is observed, or the stars may come in the order A_n, B_s, B_n, A_s, &c.

In selecting stars, every possible pair permitted by adopted limits should be roughly


a
c
d
b


m
s
n
s
p


30
20
10
0
m
n
p

represented by looping points of a line; these points corresponding to the right ascensions of the stars, the most favorable pairs can then be readily selected by inspection.

From the observations at my first station, Howell, taking the probable error of declinations in Safford's Catalogue to be = 0''.75, I deduced the following:

Number of results	74
Number of pairs	33
Probable error of observation in the half-difference of zenith-distances	0''.95
Probable error of one resulting latitude from one pair	1''.10
Probable error of weighted mean	0''.13

Part of my work was computed in the field. During the winter I have completed one computation of my observations for latitude, time, and instrumental constants, and corrected the results from recomputations. In time-work, the method by high and low stars was followed.

I have computed my local sidereal times and corresponding Detroit clock-times of coincidences, and recomputed eight nights of Lieutenant Lockwood's time-work, 1875. I have also compiled some information concerning jetty work at the mouth of the Mississippi River.

After an examination at the locality, I reported December 5, 1875, on a certain claim for land damage near Saugatuck, Mich.

I have recently been practicing with magnetic instruments for the coming season's work.

Tables are appended, giving individual time results, with adopted means and rates, results for latitude, and geographical positions of local points.

PERSONAL EQUATION.

Individual and mean results for corrections of chronometer at Detroit, Mich.

Star.	May 10. Δt of chronometer at 15h Æ.	May 12. Δt of chronometer at 15h Æ.	May 15. Δt of chronometer at 15h Æ.
	m. s.	m. s.	m. s.
2 Canum Venaticorum	−1 59. 23	−2 3. 70	
η Virginis	59. 01	3. 65	
6 Canum Venaticorum	59. 24	3. 83	
20 Comæ	59. 15	3. 62	
24 Comæ	58. 98	3. 64	
γ Virginis	59. 22	3. 53	
δ Virginis	59. 03	3. 76	
ε Virginis	59. 16	3. 75	
θ Virginis	58. 96	3. 67	
43 Comæ	59. 07	3. 75	−2 10. 70
ξ Virginis	59. 08	3. 79	10. 69
τ Bootis	58. 94	3. 79	10. 57
η Bootis	58. 78	3. 57	10. 60
τ Virginis	59. 08	3. 67	10. 83
β^1 Scorpii	58. 96	3. 51	
δ Ophiuchi	59. 06	3. 80	
ε Ophiuchi	58. 92	3. 75	
γ Herculis	59. 16	3. 75	10. 77
ω Herculis	59. 24	3. 92	10. 98
β Herculis	58. 82	3. 41	
ξ Ophiuchi	59. 09	3. 49	10. 80
ζ Herculis	59. 26	3. 70	10. 83
η Herculis	59. 18	3. 95	
49 Herculis	59. 06	3. 64	10. 91
20 Canum Venaticorum			10. 73
α Virginis			10. 67
d Bootis			10. 81
ι Virginis			10. 88
φ Virginis			10. 86
ρ Bootis			10. 82
π Bootis, pr			10. 82
λ Ophiuchi			10. 69
ε Herculis			10. 52
60 Herculis			10. 70
Gr. 2415			10. 75
ά Herculis			10. 74
α Ophiuchi			10. 61
β Ophiuchi			10. 68
Adopted means	−1 59. 070	−2 03. 693	−2 10. 748
Adopted hourly rates	— 0. 138	— 0. 091	— 0. 106

Individual and mean results for correction of chronometer at Howell, Mich.

Star.	June 18.		June 26.	
	Δt of chronometer at 17h 30m Æ.		Δt of chronometer at 17h 30m Æ.	
	m.	s.	m.	s.
β Coronæ	−12	34.95	−12	33.42
ν Bootis		34.85		33.57
3² Coronæ		34.99		33.39
γ Coronæ		35.26		33.53
ε Serpentis		35.41		33.53
γ Serpentis		35.45		33.53
β¹ Scorpii		35.39		33.85
δ Ophiuchi		35.25		33.65
ε Ophiuchi		35.39		33.32
γ Herculis		35.26		33.60
ζ Ophiuchi		35.21		33.24
ζ Herculis		35.06		33.69
η Herculis		35.21		33.65
49 Herculis		35.12		33.52
1 Aquilæ		35.20		33.24
110 Herculis		34.98		33.28
β Lyræ		35.26		33.55
θ¹ Serpentis		35.24		33.34
ε Aquilæ		35.25		33.42
ζ Aquilæ		35.41		33.63
ι Lyræ		35.18		33.65
ω Aquilæ		35.35		33.80
δ Aquilæ		35.14		33.56
β Cygni		35.08		33.60
κ Aquilæ		35.13		33.82
Adopted means	−12	35.208	−12	33.535
Adopted hourly rates	+	0.023	+	0.024

Individual results for corrections of chronometer at Lansing, Mich.

Star.	July 13.	July 19.	July 19.
	Δ*t* of chronometer at 18h 40m, Æ.	Δ*t* of chronometer at 18h 40m, Æ.	Δ*t* of chronometer at 20h 30m, Æ.
	m. s.	*m. s.*	*m. s.*
δ Ophiuchi	—14 24.84	....	....
ε Ophiuchi	24.80	—14 13.94	....
γ Herculis	25.05	13.96	....
ζ Ophiuchi	24.70	13.72	....
ζ Herculis	24.91	13.71	....
η Herculis	24.77	13.92	....
49 Herculis	24.81	13.84	....
κ Ophiuchi	24.57	13.73	....
d Herculis	24.61	14.17	....
π Herculis	24.40	14.16	....
γ Ophiuchi	24.64	14.03	....
θ Herculis	24.47	13.96	....
67 Ophiuchi	24.58	13.98	....
72 Ophiuchi	24.50	13.98	....
α^2 Capricorni	24.77	14.06	....
γ Cygni	24.60	14.06	....
π Capricorni	24.67	14.08	....
α Delphini	24.58	13.62	....
γ^2 Delphini	24.66	13.84	....
μ Aquarii	24.85	13.85	....
ν Cygni	24.71	14.08	....
61 Cygni	24.69	14.00	....
ζ Cygni	24.67	13.90	....
ε Herculis	....	13.84	....
α Ophiuchi	....	14.04	....
β Ophiuchi	....	13.97	....
ε Delphini	....	13.86	....
1 Aquilæ	....	....	—14 01.62
α Lyræ	....	....	1.58
110 Herculis	....	....	1.57
β Lyræ	....	....	1.48
θ Serpentis	....	....	1.75
ε Aquilæ	....	....	1.64
ι Lyræ	....	....	1.68
ω Aquilæ	....	....	1.82
δ Aquilæ	....	....	1.80
β Cygni	....	....	1.68
κ Aquilæ	....	....	1.97
ξ Aquarii	....	....	1.82
θ Pegasi	....	....	1.57
μ Capri	....	....	1.90
20 Pegasi	....	....	1.59
α Aquarii	....	....	1.69
θ Pegasi	....	....	1.38
θ Aquarii	....	....	1.54
γ Aquarii	....	....	1.70
π Aquarii	....	....	1.77
μ Aquarii	....	....	1.70
ζ Pegasi	....	....	1.90
λ Pegasi	....	....	1.75
μ Pegasi	....	....	1.65
Adopted means	—14 24.691	—14 13.936	—14 01.693
Adopted hourly rates	+ 0.069	+ 0.111	+ 0.091

Individual results for corrections of chronometer at Hastings, Mich.

Star.	July 30.	August 7.	August 12.
	Δ*t* of chronometer at 20h 30m Æ.	Δ*t* of chronometer at 20h 30m Æ.	Δ*t* of chronometer at 20h. 30m Æ.
	m. s.	*m. s.*	*m. s.*
1 Aquilæ	−16 51.73	−16 38.82	−16 28.01
α Lyræ	51.80	38.84	28.15
110 Herculis	51.70	38.83	27.94
β Lyrae	51.96	38.93	28.16
θ Serpentis	51.77	38.88	28.08
ε Aquilæ	51.79	38.86	27.96
ζ Aquilæ	51.58	....	27.74
ι Lyræ	51.45	38.63	27.66
ω Aquilæ	51.69	38.73	27.71
δ Aquilæ	51.66	38.87	27.84
β Cygni	51.62	38.60	27.64
κ Aquilæ	51.69	38.78	28.03
ξ Aquarii	51.53	38.78	27.89
ε Pegasi	51.48	38.53	27.95
μ Capricorni	51.81	38.70	....
20 Pegasi	51.63	38.70	27.89
α Aquarii	51.66	38.84	....
θ Pegasi	51.62	38.61	....
ϑ Aquarii	51.88	38.75	....
γ Aquarii	51.69	38.71	....
π Aquarii	51.64	38.80	....
ζ Pegasi	51.91	39.08	....
λ Pegasi	51.73	38.96	....
μ Pegasi	51.85	39.05	....
η Aquarii	....	38.78	....
λ Aquarii	....	38.89	....
Adopted means	−16 51.703	−16 38.799	−16 27.910
Adopted hourly rates	+ 0.039	+ 0.061	+ 0.083

Individual results for corrections of chronometer at Jackson, Mich.

Star.	August 28.	August 30.
	Δ*t* of chronometer at 22h Æ.	Δ*t* of chronometer at 22h Æ.
	m. s.	*m. s.*
θ Aquilæ	−0 26.21	−0 35.01
α^2 Capricorni	26.38	34.94
γ Cygni	26.23	35.06
π Capricorni	26.48	35.11
ε Delphini	26.38	35.04
α Delphini	26.45	34.71
δ Delphini	26.33	34.80
ε Aquarii	26.44	34.89
μ Aquarii	26.50	34.96
ν Cygni	26.35	34.63
61^1 Cygni	26.56	34.57
ζ Cygni	26.48	34.83
τ Pegasi	26.43	34.85
ν Pegasi	26.40	34.84
70 Pegasi	26.47	34.94
72 Pegasi	26.86	34.97
ν Andromedæ	26.48	34.83
ϕ Pegasi	26.28	34.96
ω Piscium	26.29	34.88
α Andromedæ	26.29	34.82
γ Pegasi	26.15	34.81
ν Ceti	26.40	34.87
12 Ceti	26.49	34.86
π Andromedæ	26.29	34.96
Adopted means	−0 26.402	−0 34.881
Adopted hourly rates	− 0.138	− 0 167

Individual results for corrections of chronometer at Allegan, Mich.

Star.	September 23. Δt of chronometer at 22^h Æ.	September 24. Δt of chronometer at 22^h Æ.
	m. *s.*	*m.* *s.*
θ Aquilæ	−7 48.23	−7 52.61
α² Capricorni	48.34	52.56
γ Cygni	48.27	52.48
π Capricorni	48.40	52.35
ε Delphini	48.13	52.52
α Delphini	48.34	52.28
δ Delphini	48.41	52.31
ε Aquarii	48.40	52.31
η Aquarii	48.32	52.39
ν Cygni	48.44	52.19
61¹ Cygni	48.36	52.10
ξ Cygni	48.56	52.28
τ Pegasi	48.41	52.48
ν Pegasi	48.41	52.21
70 Pegasi	48.33	52.33
72 Pegasi	48.37	52.41
ν Andromedæ	48.26	....
φ Pegasi	48.36	52.32
ω Piscium	48.20	52.47
α Andromedæ	48.42	....
γ Pegasi	48.33	....
ι Ceti	48.36	....
12 Ceti	48.20	....
π Andromedæ	48.54	....
Adopted means	−7 48.350	−7 52.367
Adopted hourly rates	− 0.224	− 0.275

Individual results for corrections of chronometer at Newago, Mich.

Star.	October 8. Δt of chronometer at $23^h\ 30^m$ Æ.	October 18. Δt of chronometer at $23^h\ 30^m$ Æ.
	m. *s.*	*m.* *s.*
ξ Aquarii	−8 40.13	−9 15.70
ε Pegasi	40.14	15.88
μ Capricorni	40.12	15.60
20 Pegasi	40.17	15.68
α Aquarii	40.37	15.79
θ Pegasi	40.17	15.59
θ Aquarii	40.18	15.71
γ Aquarii	40.55	....
π Aquarii	40.21	15.63
η Aquarii	40.19	....
ξ Pegasi	40.19	....
λ Pegasi	40.12	....
μ Pegasi	40.10	....
λ Aquarii	40.36	15.54
ι Ceti	40.26	15.60
12 Ceti	40.26	....
π Andromedæ	40.19	15.80
δ Andromedæ	40.04	15.69
β Ceti	40.23	15.80
δ Piscium	40.21	....
μ Andromedæ	40.41	15.88
ε Piscium	40.30	15.71
β Andromedæ	40.07	15.60
τ Piscium	40.25	15.54
ν Piscium	40.02	15.47
Adopted means	−8 40.208	−9 15.679
Adopted hourly rates	− 0.105	− 0.188

PERSONAL EQUATION.

Individual results for corrections of chronometer at Detroit, Mich.

Star.	November 4. Δt of chronometer at 2h Æ.	November 5. Δt of chronometer at 2h Æ.	November 10. Δt of chronometer at 1h Æ.
	m. s.	m. s.	m. s.
τ Pegasi	+ 0 31.98	+ 0 29.33	
ν Pegasi	31.88	29.32	
70 Pegasi	32.03	29.42	
72 Pegasi	31.85		
ι Piscium	32.04	29.25	+ 0 18.53
ψ Pegasi	32.07	29.24	18.57
ω Piscium	32.21	29.51	18.64
α Andromedæ	32.08	29.62	18.42
γ Pegasi	32.14	29.50	18.60
ι Ceti	32.26	29.53	18.16
12 Ceti	32.14	29.53	18.43
ε Andromedæ	32.00	29.57	18.63
41 Arietis	32.01	29.42	18.63
η Eridani	32.14	29.48	
α Ceti	32.16	29.47	
β Persei	31.95	29.41	
δ Arietis	32.04		
ζ Arietis	32.16		
o Tauri	31.92		
ξ Tauri	31.94		
f Tauri	32.08		
ε Eridani	32.04		
o Persei	32.08		
η Tauri	32.08		
π Andromedæ			18.18
ζ Andromedæ			18.41
γ Andromedæ			18.28
α Arietis			18.26
β Trianguli			18.30
ξ¹ Ceti			18.27
γ Trianguli			18.42
ξ² Ceti			18.39
ν Arietis			18.58
γ Ceti			18.69
μ Ceti			18.49
Adopted means	+ 0 32.053	+ 0 29.440	+ 0 18.442
Adopted hourly rates	− 0.164	− 0.162	− 0.183

Astronomical post at—	Number of results.	Number of pairs.	Latitude.	Probable error.	
			° ′ ″	″	
Howell, Mich	74	33	+42 36 00.24	0.13	Weighted mean.
Lansing, Mich	47	32	+42 43 53.11	0.17	Do.
Hastings, Mich	39	22	+42 38 52.85	0.19	Arithmetical mean.
Jackson, Mich	50	25	+42 14 51.02	0.17	Do.
Allegan, Mich	48	29	+42 31 43.01	0.18	Do.
Newaygo, Mich	37	27	+42 25 14.16	0.21	Do.

Geographical positions.

Station.	Points.	Latitude.	Longitude west from Greenwich.
		° ′ ″	° ′ ″
Howell, Livingston County, Mich.	Astronomical post	42 36 00.24	83 55 44.25
	Southwest corner of court-house	36 24.52	55 41.42
	Intersection of axes of Grand River and Higgins street.	36 23.25	55 42.62
	South corner of school-house	36 16.06	55 49.19
	Intersection of axes of Higgins and Monroe streets	36 11.18	55 50.78
	Northwest corner of section 1, north 2, range 4 east	35 59.63	56 01.55
Lansing, Ingham County, Mich.	Astronomical post	42 43 53.11	84 33 19.68
	Intersection of axes of Washtenaw and Washington avenues	43 47.56	33 11.16
	Intersection of axes of Capitol and Michigan avenues	43 55.79	33 16.98
	Northeast corner of Lansing House	43 47.13	33 11.94
	Northeast corner of section 16, north 4, range 2 west	44 21.87	32 37.36
	Dome of State capitol	43 56.06	33 23.17
Hastings, Barry County, Mich.	Astronomical post	42 38 52.85	85 17 18.25
	Intersection of axes of Broadway and Court streets	38 50.71	17 23.03
	Intersection of axes of State and Church streets	38 54.13	17 17.55
	Southwest corner of court-house	38 51.58	17 20.39
	Southeast corner of Hastings House	38 55.12	17 17.99
	Northwest corner of section 17, range 3 north, 8 west	39 11.65	17 23.32
Jackson, Jackson County, Mich.	Astronomical post	42 14 51.02	84 24 31.86
	Intersection of axes of Main and Jackson streets	14 49.40	24 29.96
	Intersection of axes of Main and Mechanic streets	14 49.40	24 19.22
	Northeast corner of Hibbard House	14 48.90	24 13.72
	Northwest corner of brick store on corner of Main and Franklin streets	14 49.33	24 12.40
	Northwest corner of section 2, township 3 south, 1 west	14 49.33	24 12.44
Allegan, Allegan County, Mich.	Astronomical post	42 31 43.01	85 51 08.77
	Northwest corner of county-record building	31 44.74	51 08.48
	Intersection of axes of Walnut and Trowbridge streets.	31 45.63	51 09.70
	Intersection of axes of Walnut and Hibbard streets	31 41.46	51 09.39
	Intersection of axes of Chestnut and Trowbridge streets	31 45.16	51 02.69
	Northwest corner of section 28, township 2 north, range 13 west	32 10.54	51 32.11
Newaygo, Newaygo County, Mich.	Astronomical post	43 25 14.16	85 48 03.78
	Southwest cornor of section 18, township 13 north, range 12 west.	25 26.06	48 10.44
	Intersection of axes of Woodard and State streets	25 15.45	48 04.33
	Intersection of axes of State and Justice streets	25 11.72	48 05.69
	Intersection of axes of Wood and Quarter streets	25 14.48	47 59.10
	Intersection of axes of Justice and Quarter streets	25 10.74	48 00.45

The longitude of each post was received from Lieutenant Lockwood.

Very respectfully, your obedient servant,

THOS. N. BAILEY,
Second Lieutenant of Engineers.

Maj. C. B. COMSTOCK,
Corps of Engineers, U. S. A.

APPENDIX E.—DETERMINATION OF THE ERRORS OF GRADUATION OF THE 12-INCH TROUGHTON & SIMMS THEODOLITE.

REPORT OF MR. R. S. WOODWARD, ASSISTANT ENGINEER.

LAKE-SURVEY OFFICE,
December 20, 1875.

SIR: I beg leave to present the following investigation of the effect of periodic errors of graduation in a circle reading by two opposite microscopes, with special reference to the 12-inch Troughton & Simms theodolite, and also the within determination of a formula for correcting results obtained with this instrument in the measurement of horizontal angles.

Early during the past summer, a careful examination of this instrument was begun in order to ascertain the cause of the large ranges often obtained with it, these ranges being much larger than the known sources of error would account for.

It was supposed, in the first place, that the discrepancy might be due to either one or a combination of the following causes:

1st. Defective micrometer-screws;

2d. Slipping of circle when clamped from friction of the sliding-clamp and inner axis;

3d. Difference in form of the limb in different positions from pressure of lower clamp;
4th. Accidental errors;
5th. Periodic errors.

Each of these sources of error was examined. The micrometer-screws were tested for every half-revolution of the five revolutions used in reading by measuring the distance (nearly equal to $\frac{1}{2}$ revolution) between the micrometer-wires. These measurements showed the screws to be very perfect.

It was found that by taking hold of and twisting the limb a set of from $12''$ to $15''$ can be made. The moment required to produce such a set, however, is largely in excess of the moment due to friction of the sliding clamp and inner axis, so that with proper care there need be no appreciable error from this source.

To ascertain whether the form of the limb is changed by pressure of the lower clamp, readings were taken for eccentricity with the circle in different positions, the clamp being set tightly each time, and the readings being taken on the same graduation-marks. The results showed no change.

The graduation was tested for accidental errors in two ways: first, the divisions of the limb in the vicinity of those giving anomalous results were compared with each other by micrometric measurements; second, the eccentricity and angular distance between the micrometers were computed by least squares from a large number of observations, and then the observed values were compared with those given by calculation.

Neither of these tests indicated sufficient error to account, except in a limited degree, for the ranges obtained.

Finally, from the angles read with the instrument, it has been found that the graduation has a periodic error sufficiently large to produce in certain cases a range of nearly seven seconds.

The method of determining this error and its application to several special cases are given herein.

The values of the constants involved in the periodic function should, however, depend on a larger number of observations than have yet been reduced.

Very respectfully,

R. S. WOODWARD,
Assistant Engineer.

Gen. C. B. COMSTOCK,
Superintendent United States Lake Survey.

Effect of periodic errors of graduation in an instrument, reading with two opposite microscopes.

It is proved in Chauvenet's Astronomy, vol. II, page 53, that the mean reading, on a circle, of two opposite microscopes, requires a correction for periodic error of the form

$$u_1 \sin(2z + x_1) + u_2 \sin(4z + x_2) + u_3 \sin(6z + x_3) + \text{etc.}$$

In this expression, z is the division of the limb on which the reading is made, and u_1, u_2, x_1, x_2, etc., are constants.

To determine the effect of this source of error in the measurement of angles, let—

$a =$ the angle whose value is sought;
$R_1 =$ the reading on the first station;
$R_2 =$ the reading on the second station;
$z =$ the division on which R_1 is read;
$\therefore z + a =$ the division on which R_2 is read.

The correction to R_1 is

$$u_1 \sin(2z + x_1) + u_2 \sin(4z + x_2) + \text{etc.};$$

and the correction to R_2 is—

$$u_1 \sin(2z + 2a + x_1) + u_2 \sin(4z + 4a + x_2) + \text{etc.}$$

Hence, by subtraction and reduction, we find:

$$
\begin{aligned}
a = R_2 - R_1 &+ 2u_1 \cos(2z + a + x_1) \sin a \\
&+ 2u_2 \cos(4z + 2a + x_2) \sin 2a \\
&+ 2u_3 \cos(6z + 3a + x_3) \sin 3a \\
&+ 2u_4 \cos(8z + 4a + x_4) \sin 4a \\
&+ \text{etc.}
\end{aligned}
\qquad (1)
$$

From this equation, it appears that the effect of the periodic error vanishes whenever $a = 0^\circ$ or 180°. Other things being equal, therefore, we should expect the range of individual results to be smallest on angles near 0° or 180°. It is also evident that for $a = 90^\circ$ the even terms of the series vanish.

Let us now suppose that measurements for a have been made on n different parts of the limb, separated at intervals β, such that $n\beta = 180^\circ$. Then if we denote the successive values of R_1 and R_2 by accents, and put

$$\begin{aligned} \omega_1 &= 2z + a + x_1, \\ \omega_2 &= 4z + 2a + x_2, \\ &\text{etc.,} \qquad \text{etc.,} \end{aligned}$$

we shall have by addition:

$$(2) \qquad \begin{aligned} na = \Sigma\left(R_2^{(m+1)} - R_1^{(m+1)}\right) &+ 2u_1 \sin a\, \Sigma \cos(\omega_1 + m \,.\, 2\beta) \\ &+ 2u_2 \sin 2a\, \Sigma \cos(\omega_2 + 2m \,.\, 2\beta) \\ &+ 2u_3 \sin 3a\, \Sigma \cos(\omega_3 + 3m \,.\, 2\beta) \\ &+ 2u_4 \sin 4a\, \Sigma \cos(\omega_4 + 4m \,.\, 2\beta) \\ &+ \text{etc.,} \end{aligned}$$

in which m is successively 0, 1, 2, etc., to $(n-1)$. But since $n \,.\, 2\beta = 360^\circ$, all the terms in the periodic part of this last equation vanish, except the nth, $2n$th, $3n$th, etc., which become respectively

$$\begin{aligned} &2n\, u_n \cos \omega_n \sin na, \\ &2n\, u_{2n} \cos \omega_{2n} \sin 2na, \text{ etc.} \end{aligned}$$

Hence we have

$$(3) \qquad \begin{aligned} a = \frac{\Sigma\left(R_2^{(m+1)} - R_1^{(m+1)}\right)}{n} &+ 2u_n \cos \omega_n \sin na \\ &+ 2u_{2n} \cos \omega_{2n} \sin 2na \\ &+ \text{etc.} \end{aligned}$$

From this equation it is seen that the greater the number of parts into which the semicircle is divided, the more fully will the periodic errors be eliminated. In ordinary cases, however, n may be taken so great that the periodic terms in the above equation will be inappreciable. Hence we may suppose a to be given with the required degree of accuracy by the equation

$$(4) \qquad a = \frac{\Sigma\left(R_2^{(m+1)} - R_1^{(m+1)}\right)}{n}$$

If now the value of a given by (4) be substituted in (1), we shall have the equation of condition

$$\begin{aligned} a - (R_2' - R_1') = 2u_1 \cos \omega_1 \sin a & \\ + 2u_2 \cos \omega_2 \sin 2a & \\ + 2u_3 \cos \omega_3 \sin 3a & \\ + \text{etc.} & \end{aligned}$$

or, if we put $v^{(m+1)} = a - \left(R_2^{(m+1)} - R_1^{(m+1)}\right)$, the general equation is

$$(5) \qquad \begin{aligned} v^{(m+1)} = 2u_1 \cos(\omega_1 + m \,.\, 2\beta) \sin a & \\ + 2u_2 \cos(\omega_2 + 2m \,.\, 2\beta) \sin 2a & \\ + 2u_3 \cos(\omega_3 + 3m \,.\, 2\beta) \sin 3a & \\ + \text{etc.} & \end{aligned}$$

in which m is successively 0, 1, 2, 3, etc., to $(n-1)$.

Developing the cosines, we get

$$(6) \qquad \begin{aligned} v^{(m+1)} = 2\sin a\,(\cos m \,.\, 2\beta\, u_1 \cos \omega_1 - \sin m \,.\, 2\beta\, u_1 \sin \omega_1) & \\ + 2\sin 2a\,(\cos 2m \,.\, 2\beta\, u_2 \cos \omega_2 - \sin 2m \,.\, 2\beta\, u_2 \sin \omega_2) & \\ + 2\sin 3a\,(\cos 3m \,.\, 2\beta\, u_3 \cos \omega_3 - \sin 3m \,.\, 2\beta\, u_3 \sin \omega_3) & \\ + \text{etc.} & \end{aligned}$$

In this equation, the unknown quantities are

$$u_1 \cos \omega_1,\ u_1 \sin \omega_1,\ u_2 \cos \omega_2,\ u_2 \sin \omega_2, \text{ etc.}$$

Hence, by least squares, we find,

$$
(7)\qquad
\begin{cases}
n\,u_1 \cos \omega_1 = \dfrac{\Sigma\,(v^{(m+1)} \cos m\,.\,2\,\beta)}{\sin a} \\[2ex]
n\,u_1 \sin\ \omega_1 = -\,\dfrac{\Sigma\,(v^{(m+1)} \sin m\,.\,2\,\beta)}{\sin a}
\end{cases}
\qquad
\begin{cases}
n\,u_2 \cos \omega_2 = \dfrac{\Sigma\,(v^{(m+1)} \cos 2\,m\,.\,2\,\beta)}{\sin 2\,a} \\[2ex]
n\,u_2 \sin\ \omega_2 = -\,\dfrac{\Sigma\,(v^{(m+1)} \sin 2\,m\,.\,2\,\beta)}{\sin 2\,a}
\end{cases}
\qquad
\begin{cases}
n\,u_3 \cos \omega_3 = \dfrac{\Sigma\,(v^{(m+1)} \cos 3\,m\,.\,2\,\beta)}{\sin 3\,a} \\[2ex]
n\,u_3 \sin\ \omega_3 = -\,\dfrac{\Sigma\,(v^{(m+1)} \sin 3\,m\,.\,2\,\beta)}{\sin 3\,a}
\end{cases}
$$

etc. etc.

These equations will serve to determine u_1, u_2, u_3, ω_1, ω_2, ω_3, etc. Then, since

$$
\begin{aligned}
\omega_1 &= 2\,z + \quad\ + x_1, \\
\omega_2 &= 4\,z + 2\,a + x_2, \\
\omega_3 &= 6\,z + 3\,a + x_3, \\
&\text{etc.} \qquad \text{etc.},
\end{aligned}
$$

we can find x_1, x_2, x_3, etc.

In the practical application of equations (7) it will be expedient to have a near 90° in determining u_1 and ω_1, a near 45° in determining u_2 and ω_2, and so on, since the accidental errors involved in the residuals expressed by $v^{(m+1)}$ will then have the least effect. This is also apparent from equation (1).

Determination of the constants u_1, u_2, x_1, x_2, for the 12-inch T. & S. theodolite.

To compute u_1 and x_1, we take the results obtained on the angle at Gasport, between Falkirk and Pekin, and construct the following table. Each of the values in the column headed $(R_2^{(m+1)} - R_1^{(m+1)})$ is the mean of 4 combined results, so that errors of observation, collimation, twist, etc., are eliminated as nearly as possible.

$n = 6$ $\qquad z = 70°\ 27'$ $\qquad a = 97°\ 22'\ 35''.77$ $\qquad \beta = 30°$

$R_2^{(m+1)} - R_1^{(m+x^1)}$	$v^{(m+1)}$	$m\,.\,2\,\beta$	$v^{(m+1)} \cos m\,.\,2\,\beta$	$v^{(m+1)} \sin m\,.\,2\,\beta$
″	″	°		
36.80	−1.03	0	−1.03	
33.54	+2.23	60	+1.11	+2.23 sin 60°
31.75	+4.02	120	−2.01	+4.02 sin 60°
34.06	+1.71	180	−1.71	
38.67	−2.90	240	+1.45	+2.90 sin 60°
39.83	−4.06	300	−2.03	+4.06 sin 60°
35.77			−4.22	+13.21 sin 60°

Hence,

$$6\,u_1 \cos \omega_1 = -\,\frac{4.22}{\sin a}$$

$$6\,u_1 \sin \omega_1 = -\,\frac{13.21 \sin 60°}{\sin a}$$

To find x_1 we have,

$z = 70°\ 27'$		log 13.21	1.12090
		log sin 60°	9.93753
$2\,z = 140°\ 54'$			1.05843
		log 4.22	0.62531
$a = 97°\ 23'$		log tan ω_1	0.43312
$2\,z + a = 238°\ 17'$		$2\,z + a + x_1 = \omega_1 =$	249° 45′
		$2\,z + a =$	238° 17′
		$x_1 =$	11° 28′

To find u_1,

log 13.21 sin 60°	1.05843	log 4.22	0.62531
a. c. log sin ω_1	0.02771	a. c. log cos ω_1	0.46083
a. c. log sin a	0.00359	a. c. log sin a	0.00359
log 6 u_1	1.08973		1.08973

$$6\,u_1 = 12''.295$$
$$u_1 = 2''.049$$

The value of a in the preceding case being so near 90°, it will be necessary to compute u_2 and x_2 from another angle.

Taking the angle Pinnacle Hill—Scottsville—Turk Hill, we have the following table:

$n = 6$ $z = 310°\ 04'$ $a = 46°\ 12'\ 00''.25$ $\beta = 30°$

$R_2^{(m+1)} - R_1^{(m+1)}$	$v^{(m+1)}$	$2m \cdot 2\beta$	$v^{(m+1)} \cos 4m\beta$	$v^{(m+1)} \sin 4m\beta$
″	″	°		
58.69	+1.52	0	+1.52	
57.40	+2.85	120	−1.42	+2.85 sin 60°
60.35	−0.07	240	+0.03	+0.07 sin 60°
63.22	−2.90	0	−2.90	
61.31	−1.06	120	+0.53	−1.06 sin 60°
60.58	−0.33	240	+0.16	+0.33 sin 60°
60.25			−2.08	+2.19 sin 60°

Hence we have,

$$6\,u_2 \cos \omega_2 = -\frac{2.08}{\sin 2a}$$

$$6\,u_2 \sin \omega_2 = -\frac{2.19 \sin 60°}{\sin 2a}$$

Proceeding with the calculation as in the preceding case,

	log 2.19	0.34044
	log sin 60°	9.93753
$z = 310°\ 04'$		0.27797
	log 2.08	0.31806
$4z = 160°\ 16'$	log tan ω_2	9.95991

$2a = 92°\ 24'$ $4z + 2a + x_2 = \omega_2 = 222°\ 22'$

$4z + 2a = 252°\ 40'$ $4z + 2a = 252°\ 40'$

$x_2 = 329°\ 42'$

log 2.19 sin 60°	0.27797	log 2.08	0.31806
a. c. log sin ω_2	0.17149	a. c. log cos ω_2	0.13138
a. c. log sin $2a$	0.00039	a. c. log sin $2a$	0.00039
log 6 u_2	0.44985		0.44983

$$6\,u_2 = 2''.817$$
$$u_2 = 0''.469$$

In the succeeding pages u_1 and x_1 are deduced from three other angles, and u_2 and x_2 from one other angle.

* * * * * * *

Collecting the different values for u_1, u_2, x_1, and x_2, we have,

u_1	u_2	x_1	x_2
$''$	$''$	$^\circ$ $'$	$^\circ$ $'$
2.049	0.469	+11 28	329 42
1.632	0.296	− 1 13	323 29
1.810		+14 22	
1.483		−11 06	
6.974	0.765	+13 31	653 11

Hence we get the following mean values:

$$u_1 = 1''.743 \qquad x_1 = 3^\circ\ 23'$$
$$u_2 = 0''.382 \qquad x_2 = 326^\circ\ 35'$$

Substituting these mean values in equation (1), it becomes

$$a = R_2 - R_1 + 3''.49 \cos(2z + a + 3^\circ) \sin a$$
$$+ 0''.76 \cos(4z + 2a + 327^\circ) \sin 2a$$

From this it appears that the correction to $(R_2 - R_1)$ depends almost wholly on the first term of the periodic part. It appears also that when $\cos(2z + a + 3^\circ) \sin a$ is a maximum, the range of the different values of $(R_2 - R_1)$ should be $2 \times 3''.49 = 6''.98$.

The correction to the mean reading of the two microscopes is

$$1''.74 \sin(2z + 3^\circ) + 0^\circ.37 \sin(4z + 327^\circ)$$

To test the accuracy of the periodic function thus found, we construct the table given below from the results obtained on an angle not used in the previous calculation. Each value of $(R_2 - R_1)$ in this table is a mean of two combined results, so that errors of observation, twist, and collimation may be assumed to be well eliminated. The agreement between the corrected results shows that the remaining discrepancies are well accounted for by the hypothesis of periodic errors.

Angle Sugar Loaf—Font Hill—Grand River.

$$n = 6 \qquad \beta = 30^\circ$$
$$z = 107^\circ\ 52' \qquad a = 55^\circ\ 25'$$

$$2z + a + 3^\circ = 274^\circ\ 09'$$
$$4z + 2a + 327^\circ = 149^\circ\ 18'$$

$(R_2 - R_1)$	*Corrections.*	*Corrected results.*
$''$	$''$ $''$ $''$	$''$
23.35	+0.21 − 0.61 = − 0.40	22.95
21.05	+2.59 − 0.01 = + 2.58	23.63
22.15	+2.38 + 0.62 = + 3.00	25.15
25.23	−0.21 − 0.61 = − 0.82	24.41
29.93	−2.59 − 0.01 = − 2.60	27.33
28.10	−2.38 + 0.62 = − 1.76	26.34
25.50	− 0.40	25.10
20.45	+ 2.58	23.03
24.35	+ 3.00	27.35
26.30	− 0.82	25.48
27.38	− 2.60	24.78
27.15	− 1.76	25.39

Range of results before correction .... 9''.48
Range of results after correction .... 4''.40

R. S. WOODWARD,
Assistant Engineer.

Gen. C. B. COMSTOCK,
Superintendent United States Lake Survey.

APPENDIX F.—LEVELING OBSERVATIONS.

REPORT OF MESSRS. L. L. WHEELER AND F. W. LEHNARTZ, ASSISTANT ENGINEERS.

OFFICE UNITED STATES LAKE SURVEY,
February 10, 1876.

GENERAL: We have the honor to submit the following report on leveling operations during the summer of 1875.

The object of this leveling was to determine with as much accuracy as possible the elevation of the great lakes above the level of the sea. For this purpose, water-level observations were taken at Oswego, Charlotte, Port Dalhousie, Port Colborne, Cleveland, Rockwood, Lakeport, Escanaba, and Marquette, during the months of May, June, July, and August, to determine the mean elevation of the lakes with reference to certain fixed bench-marks established at those places. The gauge at Rockwood was referred to bench-marks in Gibraltar, 2½ miles distant. The bench-marks at Oswego were to be connected by duplicate lines of levels with certain bench-marks at Greenbush, N. Y., the elevation of which above mean tide at New York had previously been determined by the United States Coast Survey. The bench-marks at Port Dalhousie were to be connected with those at Port Colborne, those at Gibraltar with those at Lakeport, and those at Escanaba with those at Marquette, in a similar manner. The bench-marks at Oswego were to be connected with those at Charlotte and Port Dalhousie, those at Port Colborne with those at Cleveland and Gibraltar, and those at Lakeport with those at Escanaba, by a comparison of water-level observations, it being assumed that the mean water-surface of the lakes during the summer months is level from one end of the lake to the other.

This report is, therefore, divided into two parts:

I. Leveling by means of the spirit-level.

II. Leveling by means of water-level observations.

I.—LEVELING BY MEANS OF THE SPIRIT-LEVEL.

For this work, two parties were detailed; Assistant Lehnartz having charge of the first, and Assistant L. L. Wheeler having charge of the second party.

1st. *Instruments used.*—The instruments used in this work were: Stackpole level, No. 1496, 11 inches focal length, and object-glass of 1¼ inches diameter, and magnifying power of 24, and Würdemann level No. 2, 17 inches focal length, and object-glass of 1¼ inches diameter. The spirit-level in each instrument is attached to the lower side of the telescope, and the value of one division of the level tube 6.″42 and 3.″17 respectively.

The leveling-rods were of the pattern known as New York rods, were graduated to hundredths of a foot, and read by vernier to thousandths of a foot. They were supported, while being used, on steel pins, eight inches long, driven into the ground.

2d. *Method of leveling.*—The method of leveling was as follows: At the end of each day's work the first party established two permanent bench-marks; also one at midday, if one could be obtained. Where it was not possible to establish permanent bench-marks at the end of a day's work, three stakes, at least one foot long, were driven into the ground, 20 feet apart, until their tops were even with the surface of the ground, and used as stopping points. A description of these bench-marks, with their elevations, was sent to the second party, who determined the elevation of the same bench-marks. The second party had instructions, that, when the difference of elevation of a bench-mark and the preceding one differed from the first party's determination by more than 0.1 foot × (distance in miles) ½, the line should be run twice again to ascertain which party was in error. This was necessary only twice throughout the season.

In working, the instrument was set up at a convenient distance from the bench-marks, and readings taken on the bench-marks. The rodman then drove the steel pin at the same distance from the instrument as the bench-marks, and a reading was taken on the pin. The instrument was then set up beyond the pin and the work continued in this manner. The length of sight, where possible, was 200 feet, determined by pacing, and back-sights and fore-sights were always taken of equal length. The instrument was carefully adjusted each morning before commencing work, and also at any time during the day, when, for any reason, it was supposed that it might be out of adjustment. Each time the instrument was set up, it was carefully leveled, so as to turn in azimuth with little displacement of the bubble, but instead of trying to have it perfectly level at the instant of pointing, the scale readings of the ends of the bubble were noted and recorded. The value of the divisions of the levels were determined before leaving the office, and a table prepared, showing the correction to be applied to the readings of the rod for a given distance, (never to exceed 200 feet,) and a given inclination of the level-tube, (never to exceed 5 level divisions.) The instrument was sheltered from the sun by an umbrella.

The value of the divisions of the levels was redetermined after returning to the

office. It was found that the value of one division of Stackpole level changed very materially with the temperature. The leveling-rods were compared with the standard meter, both before leaving and after returning to the office, and the proper corrections have been made to elevations determined with them.

3. *History of summer's work.*—The following is a brief history of operations during the summer:

The party under charge of Mr. Lehnartz left Detroit May 4, established the water-gauge stations at Port Colborne, Port Dalhousie, and Oswego, and commenced work at Greenbush May 13. Oswego was reached by this party August 15. Work was commenced at Port Dalhousie August 16, and Port Colborne reached September 2. Work was commenced at Rockwood September 7, and Lakeport reached October 28.

The party under charge of Mr. Wheeler left Detroit May 6, established water-gauge stations at Gibraltar, Rockwood, and Lakeport, examined water-gauge station at Sacket's Harbor, and commenced work at Greenbush May 28. Oswego was reached October 15 and Port Colborne October 29. This party was delayed during the summer by needed repairs of instrument and by releveling of lines.

The route followed by both parties was along Erie Canal to Higginsville, along wagon-roads to Fish Creek, and along the New York and Oswego Midland Railroad to Oswego. The Welland Railway was followed from Port Dalhousie to Port Colborne.

The average distance run by the first party per day, including days on which no work was done, was 1.97 miles, and by the second party 1.89 miles.

Throughout the season, E. S. Davis and J. B. Johnson, recorders, acted as rodmen, and deserve much credit for the care with which they performed their duties and the interest manifested in the work.

4. *Levels from Greenbush to Oswego.*—The bench-marks at Greenbush were established by the United States Coast Survey. The following extract from letter of J. E. Hilgard contains the data for elevation of bench-marks at Greenbush:

"UNITED STATES COAST SURVEY OFFICE,
"*March* 20, 1875.

"*Levels between New York and Albany.*—The two levelings of Mr. Vose in 1857–'58 give the following results:

	Feet.	Feet.
"Greenbush bench-mark at Boston and Albany Railroad bridge	0.000	0.000
* * * * * * *		
"New York, Hudson River, Eighteeenth-street bench-mark	11.066	11.040
"From these figures we conclude that the difference of level between the benches at New York and Albany (Greenbush) is 11.05 feet, with no greater uncertainty than ± 0.1 foot mean		11.053
"Zero of tide-staff at New York, Eighteenth street, below bench-mark		18.665
"Zero of tide-staff below bench-mark at Albany		29.718
"Mean tide (referred to Governor's Island) above zero		3.78
"Mean tide at New York below bench-mark at Albany		25.94

"J. E. H.

"*Bench-marks near Albany.*—The bench-mark to which the preceding levels are referred is on the stone abutment of the Boston and Albany Railroad bridge at Greenbush, a copper bolt in the northwest side of the northeast corner, on the third tier of stones. (See accompanying sketch.)

"There is another bench-mark at Greenbush, on the southwest upper corner of the lower tier of stones, at the northwest corner of the culvert, a few rods south of the one on the railroad-bridge. It is 9.316 feet lower than the latter.

"Another bench-mark is on the steam grist-mill at Greenbush, a cross-cut on the northwest side of the northeast corner of stone foundation, (see sketch.) It is 10.564 feet lower than the one on the railroad-bridge.

"The bench-mark on the railroad-bridge was established in 1856, and was then found to be 29.081 feet above miter-sill of southwest or lower lock in basin in Albany; also 28.985 feet above miter-sill of northeast lock." (See letter of J. E. Hilgard, March 24, 1875.)

In consequence of the rebuilding (1861 or '62) of the bridge and culvert on which the first and second of these bench-marks were placed, those bench-marks were lost, and only the third remained.

The Coast Survey data give this bench-mark 10.564 feet below the bench-marks on the railroad-bridge. Hence the bench-mark on the grist-mill is 15.374 feet above mean tide at Governer's Island.

Since the two bench-marks on the railroad structures had been lost, there was no check on the bench-mark on the grist-mill, except the difference in elevation between it and the lower miter-sill of lock No. 1 of the Erie Canal. According to the data

furnished by the Coast Survey this difference is 18.52 feet. Assistant Lehnartz determined this difference, and found it to be 20.99 feet. Lieutenant Willard, Corps of Engineers, United States Army, has also determined this difference, and found it to be 20.89 feet. This shows a discrepancy of about 2.5 feet between the determination of 1856 and the new determination.

A line of levels, run under the direction of Lieutenant Willard, Corps of Engineers, between the Coast Survey bench-marks at Stuyvesant and that on grist-mill at Greenbush, a distance of about 30 miles, gives a result differing by 0.5 foot from the Coast Survey determination, showing that the difference of 2.5 feet cannot be due to an erroneous elevation of the bench-mark on the grist-mill. (See letter of Lieutenant Willard, December 14, 1875.) It is impossible, however, to obtain definite information in regard to changes that may have taken place in the elevation of the miter-sill, but it is believed that the miter-sill has been lowered 2.5 feet since the Coast Survey determination.

Another bench-mark was established at Greenbush, and connected by duplicate levels with the bench-mark on the mill. It is a copper bolt, 4 inches long, ¾-inch diameter, leaded into springing stone of north arch of culvert on north side of culvert and west side of railroad. The upper side of bolt-head is considered to be the bench-mark. The letters B. M. were cut in the masonry near the bolt. It is 0.134 foot higher than the bench-mark on the mill.

The upper surface at the southwest corner of the west end of the flank wall on the north side of culvert and west side of railroad was found to be 0.563 foot above the bench-mark on mill. A cross and the letters B. M. were cut in the upper surface of the stone.

The culvert above mentioned is a few rods south of the Boston and Albany Railroad bridge over Second avenue, Greenbush.

The following bench-marks were established at Oswego:

B. M. "A."—Top of iron bolt in top of masonry of old Government pier, 0.5 foot from east face of pier, 3.5 feet north of northwest corner of United States Engineer's Store-house on United States reservation, marked U. S. + B. M. (foot of Third street.) It is 252.608 feet above mean tide at Governor's Island.

B. M. "B."—Top of stone post (highest point, marked U. S.,) surface flush with ground, in prolongation south of west face of old stone pier. The stone marking southwest boundary of United States reservation, 8 feet south of masonry of pier, 28 feet west of southwest corner of Engineer's Store-house. It is 0.513 foot above bench-mark A.

B. M. "C."—Cross cut on "Shop of Dry Dock of Marine Railway." Third course of stones from ground on west side of shop 3 feet from southwest corner, (shop on corner of Lake and Second streets.) It is 10.076 feet above bench-mark A.

The tide-gauge is on a post on north side of store house, about 10 feet from bench-mark A. The zero of the gauge is 7.754 feet below bench-mark A.

Table A contains a list of bench marks between Greenbush and Oswego, and their elevations.

The first column contains a list of bench-marks; the second column gives the distance of each bench-mark from Greenbush; the third and fourth columns give the date of each party's connecting with the bench-mark. The fifth column contains elevation of bench-marks, corrected for error of rod, as determined by Mr. F. W. Lehnartz. The sixth column shows the discrepancy between the two determinations of the difference of elevation of a bench-mark and the preceding one. The plus-sign indicates that the second party makes the elevation greater than the first party. The seventh column contains the sum of these discrepancies. The eighth column gives the mean elevation of each bench-mark. In forming this mean, all determinations are given equal weight. Wherever a star appears in the fifth column several determinations of difference of elevation have been made, and the mean applied to the elevation of the preceding bench-mark.

The elevations given in the table are above mean tide at Governor's Island, New York, on the supposition that the bench-mark on the mill at Greenbush is 15.374 feet above the same datum-plane.

5. *Levels between Port Dalhousie and Port Colborne.*—The following bench-marks were established at Port Dalhousie:

B. M. "A".—Top of stone-post buried under sidewalk, corner of Canal and Lock streets, 10½ feet from southeast corner of Wood House, on perpendicular to east side of Wood House, toward canal, about 110 feet west of heel-post of west gate of north end of canal-lock. It is 5.982 feet above bench-mark B.

B. M. "B."—Edge of cut in top-course of masonry in north recess in east wall of canal, 20 feet north of northeast gate of lock. This bench-mark is the zero of the gauge, and elevations of bench-marks along the Welland Railway are given with reference to it.

B. M. "C."—Cross cut into stone of foundation of Collector's Office, third course of stones from top, north side 1.4 feet from northwest corner. It is 0.177 foot above bench-mark B.

The following bench-marks were established at Port Colborne :

B. M. on Custom-House.—Top of point of iron bolt set in masonry of stone foundation of custom-house, west side, southwest corner. It is 326.583 feet above bench-mark B, at Port Dalhousie.

B. M. on Baptist Church.—Top of point of iron bolt in east end of window-sill in basement of steeple, south side, of Baptist Church. It is 4.202 feet below the bench-mark on the custom-house.

B. M. on Church of England.—Top of point of iron bolt in stone foundation, lower tier of stones in south side of Church of England, (street front, east side of entrance.) It is 5.653 feet below bench-mark on Custom-House.

The zero of tide-gauge is highest point of iron bolt in top-course of masonry in south recess of south extension of west wall of canal-lock, just above swing-bridge. It is 3.866 feet below bench-mark on custom-house.

Table B contains the elevation of bench-marks between Port Dalhousie and Port Colborne, above bench-mark B at Port Dalhousie.

The explanation already given with regard to Table A applies to Table B.

The following bench-marks were established in connection with the gauge at Rockwood.

B. M. 1.—A small cross on the stone window-sill of the south window on the west side of the brick house of Mr. Craig, corner of Farnsworth and Adams streets, Gibraltar, Michigan. It is 1.976 feet above bench-mark 2.

B. M. 2.—The southeast corner of the store door-sill of the door in the southeast angle of the light-house at Gibraltar. The zero of the gauge at Rockwood and the other bench-marks have been referred to this bench-mark.

B. M. 3.—The highest point of a large rock 120 feet southeast of the southeast corner of log-house on the Story farm. It is 10.677 feet below bench-mark 2. *The zero of the gauge* is the highest point of a spike driven into a post supporting the runway of the ice-house on the Story farm. It is 8,740 feet below bench-mark 2.

II.—LEVELING BY MEANS OF WATER-LEVEL OBSERVATIONS.

At each station where water-level observations were taken three permanent bench-marks were established and their elevation with reference to the zero of the gauge determined. Readings were taken at 7 a. m., 1 p. m., and 7 p. m. each day. At Oswego, the tide-gauge consists of a strap of iron spiked to a post and graduated to tenths of a foot, the graduation commencing at a point below the surface of the water and extending upward. Readings at this station, therefore, show the height of the surface of the water above the zero of the gauge. At the other stations measurements were taken by measuring down from a fixed point to the surface of the water with a rod graduated to hundredths of a foot. These measurements, therefore, show the height of the fixed point (zero of gauge) above the surface of the water.

1st. *Lake Ontario.*—The following tables show the monthly mean readings of the gauges at the stations on Lake Ontario.

Since the readings at Oswego show how much the surface of the water is *above* the zero of the gauge, and at the other stations how much it is *below* the zero of the gauge, the readings at Oswego and Charlotte, or Oswego and Port Dalhousie should show a constant sum, and the readings at Charlotte and Port Dalhousie, should show a constant difference. In the means given in the tables, the mean for each month has been given weight according to the number of days during which observations were taken.

Month.	Charlotte.	Oswego.	Sum.
	Feet.†	*Feet.*	*Feet.*
May*	4. 38 − 1. 47 = 2. 91	1. 65	4. 56
June	2. 78	1. 73	4. 51
July	2. 64	1. 81	4. 45
August	2. 82	1. 63	4. 45
Mean	2. 78	1. 71	4. 49

* Observations during May extend from May 11 to May 31, inclusive.
† The May record at Charlotte is reduced to the new zero.

Month.	Charlotte.	Port Dalhousie.	Difference.
	Feet.	*Feet.*	*Feet.*
May	2. 91	12. 21	9. 30
June	2. 78	12. 12	9. 34
July	2. 64	12. 04	9. 40
August	2. 82	12. 19	9. 37
Mean	2. 78	12. 13	9. 36

Month.	Oswego.	Port Dalhousie.	Sum.
	Feet.	*Feet.*	*Feet.*
May	1. 65	12. 21	13. 86
June	1. 73	12. 12	13. 85
July	1. 81	12. 04	13. 85
August	1. 63	12. 19	13. 82
Mean	1. 71	12. 13	13. 84

Combining the results of the two methods of leveling, we have the following results:

	Feet.
Mean tide at Governor's Island, N. Y	0. 000
Bench-mark on grist-mill at Greenbush, N. Y	15. 374
Bench-mark A, at Oswego	252. 608
Zero of gauge at Oswego below bench-mark A	7. 754
Zero of gauge above mean tide	244. 854
Mean surface of water (May 11 to August 31) above zero	1. 71
Elevation of mean surface of Lake Ontario from May 11 to August 31, inclusive.	246. 56
Mean surface of water at Charlotte from May 11 to August 31, inclusive, below zero of gauge, (new)	2. 78
Elevation of zero	249. 34
Bench-mark on light-house at Charlotte above zero, (office 219)	34. 53
Elevation of bench-mark on light-house	283 87
Mean surface of Lake Ontario from January 1, 1860, to December 31, 1875, below bench-mark on light-house, (office 486)	36. 62
Elevation of mean surface of Lake Ontario from January 1, 1860, to December 31, 1875	247 25

2d. *Lake Erie.*—The following tables show the monthly mean readings of the gauges at the stations on Lake Erie.

Since the readings in every case are taken by measuring down from a fixed point to the surface of the water, the water-level readings at any two stations on Lake Erie should show a constant difference. In the means given in the tables, the mean for each month has been given weight according to the number of days during which observations were taken:

Month.	Cleveland.	Port Colborne.	Difference.
May*	5. 32	7. 97	2. 65
June	5. 21	7. 83	2. 62
July	5. 08	7. 69	2. 61
August	5. 09	7. 73	2. 64
Mean	5. 15	7. 78	2. 63

Month.	Cleveland.	Rockwood.	Difference.
May	5. 32	3. 42	1. 90
June	5. 21	3. 34	1. 87
July	5. 08	3. 21	1. 87
August	5. 09	3. 09	2. 00
Mean	5. 15	3. 24	1. 91

Month.	Port Colborne.	Rockwood.	Difference.
May	7.97	3.42	4.55
June	7.83	3.34	4.49
July	7.69	3.21	4.48
August	7.73	3.09	4.64
Mean	7.78	3.24	4.54

* Observations during May extended from May 19 to May 31, inclusive.

		Feet.
Elevation of mean surface of Lake Ontario from May 11 to August 31, inclusive		246.56
Bench-mark "B" at Port Dalhousie, above same surface		12.13
Elevation of bench-mark "B"		258.69
Bench-mark on custom-house at Port Colborne, above bench-mark "B"		326.59
Elevation of bench-mark on custom-house		585.28
	Feet.	
Zero of gauge below bench-mark on custom-house	3.87	
Zero of gauge above mean surface of Lake Erie from May 19 to August 31, 1875, inclusive	7.78	
		11.65
Elevation of mean surface of Lake Erie from May 19 to August 31, 1875		573.63
Zero of gauge at Cleveland above same plane		5.15
Elevation of zero of gauge		578.78
Zero of gauge below coping on Ohio Canal, (office 291)		3.44
Elevation of coping on Ohio Canal		582.22
Mean surface of Lake Erie from January 1, 1860, to December 31, 1875, below coping on canal, (office 486)		8.64
Elevation of mean surface of Lake Erie from January 1, 1860, to December 31, 1875		573.58
The zero of the gauge at Rockwood is above the mean surface of Lake Erie, from May 19 to August 31		3.24
Bench-mark 2, above zero of gauge		8.74
Mean surface of Lake Erie from May 19 to August 31 above mean tide at Governor's Island, N. Y		573.63
Bench-mark 2 above mean-tide at Governor's Island, N. Y		585.61

3d. *Influence of the winds on water-surfaces.*—In order to ascertain the probable effect of the winds on the surface of the water, a comparison has been made of the mean daily measurements at Oswego and Port Dalhousie with the record of the winds at Rochester; also of the mean daily measurements at Port Colborne and Rockwood with the record of the winds at Cleveland. The following table contains the mean results for Lake Ontario for the eight principal points of the compass. The quantities in the column marked "results" show how much the zero of the gauge at Port Dalhousie is above the zero of the gauge at Oswego. Days when the velocity of the wind exceeded ten miles per hour are considered storm-days.

Direction of wind.	Rejecting storm-days.			Without rejecting storm-days.		
	Number of days.	Results.	Range.	Number of days.	Results.	Range.
		Feet.	Feet.		Feet.	Feet.
North	3	13.86	0.14	3	13.86	0.14
Northeast	3	13.82	0.18	4	13.86	0.22
East	4	13.81	0.19	4	13.81	0.19
Southeast	7	13.81	0.50	8	13.75	0.50
South	25	13.82	0.32	25	13.82	0.32
Southwest	31	13.81	0.38	34	13.83	0.43
West	20	13.89	0.39	28	13.89	0.39
Northwest	3	13.87	0.10	6	13.93	0.23
Calm	1	13.63	0.00	1	13.63	0.00

The length of Lake Ontario extending east and west, the easterly and westerly winds would have the greatest, and the north and south winds the least, effect on the surface of the water. This is shown by the following means of the results for the various directions:

Direction of wind.	Storm-days rejected.	Storm-days not rejected.
	Feet.	*Feet.*
North and south	13.84	13.84
Northeast, east, and southeast	13.81	13.81
Southwest, west, and northwest	13.86	13.88

The mean of all observations during the summer makes the zero of the gauge at Port Dalhousie 13.84 feet above the zero of the gauge at Oswego. From these results we conclude that the error in leveling from Oswego to Port Dalhousie by water-level observations, due to wind alone, cannot exceed 0.04 feet.

The following table contains the mean results for Lake Erie for the eight principal points of the compass. The quantities in the columns marked "results" show how much the zero of the gauge at Port Colborne is above the zero of the gauge at Rockwood.

Direction of wind.	Rejecting storm-days.			Without rejecting storm-days.		
	Number of days.	Results.	Range.	Number of days.	Results.	Range.
		Feet.	*Feet.*		*Feet.*	*Feet.*
North	7	4.42	0.53	11	4.38	0.53
Northeast	5	4.95	0.98	5	4.95	0.98
East	10	4.80	0.56	10	4.80	0.56
Southeast	27	4.68	1.44	33	4.68	1.44
South	25	4.33	1.50	27	4.28	1.81
Southwest	11	4.48	0.93	13	4.45	1.01
West	4	4.25	0.70	5	4.20	0.70
Northwest	1	4.44	0.00	1	4.44	0.00

It is assumed in this discussion that since the length of Lake Erie extends from east-northeast to west-southwest, southeast and northwest winds have the least effect on the level of the lake, and the following means have been taken with reference to this assumption:

Direction of wind.	Storm-days rejected.	Storm-days not rejected.
	Feet.	*Feet.*
Southeast and northwest	4.56	4.56
North, northeast, and east	4.72	4.71
South, southwest, and west	4.35	4.31

The mean of all observations during the summer makes the zero of the gauge at Port Colborne 4.54 feet above the zero of the gauge at Rockwood.

From these results we conclude that the error in leveling from Port Colborne to Rockwood by water-level observations, due to winds alone, cannot exceed 0.1 foot.

Very respectfully, your obedient servants,

L. L. WHEELER,
F. W. LEHNARTZ,
Assistant Engineers.

Gen. C. B. COMSTOCK,
Superintendent United States Lake Survey.

NOTE.—The accuracy of the results of the work herein reported depends on the precision of the different steps. Those steps are as follows:

1st. Height of Coast Survey bench-mark on grist-mill at Greenbush above mean tide at New York, 15.374 feet, with probable error given by Coast Survey of ± 0.1 foot.

2d. Height of Lake Survey bench-mark A at Oswego above Coast Survey bench-mark on grist-mill at Greenbush, 237.234. Deriving the probable error of this result from the total discrepancy between the two lines of levelings, it is found to be ±0.32 foot. This probable error is larger than was expected, although the instruments were ordinary levels, as a good deal of care was taken in the work. On examining Table A, appended, it will be seen that for the first 70 miles from Greenbush the discrepancies between the two lines of levels over short distances of 2 or 3 miles had no marked bias as to sign; and that at 70 miles the total discrepancy was but 0.13 foot. But for the rest of the distance to Oswego, 117 miles, the plus sign predominates, and the total discrepancy increases to 0.953 foot. Careful examination has been made to find some reason for the discrepancies over short distances having so steadily the same sign, but in vain. It is hoped to repeat this part of the work.

3d. Lake Survey bench-mark B, at Port Dalhousie, above Lake Survey bench-mark A, at Oswego, 6.082 feet. This difference of elevation is obtained by referring the mean heights of Lake Ontario, from May 11 to August 31, 1875, at the two stations to the two bench-marks, and assuming that for the period named those mean heights were at the same level. Winds and barometric changes make this assumption inexact. The latter will be eliminated in so long a period, and a comparison of the gauge-readings at the two places with the directions of the winds seems to show that the wind-effect is well eliminated in the mean, and that a sufficient allowance will be made for probable error if it is called ±0.04 foot.

4th. Lake Survey bench-mark on custom-house, Port Colborne, above Lake Survey bench-mark B, at Port Dalhousie, 326.588 feet. The two lines of levels agree well, and give for probable error in this result ±0.02 foot.

Lake Survey bench-mark No. 2, at Gibraltar, above Lake Survey bench-mark on custom-house, Port Colborne, 0.33 foot. This difference is obtained in the same way as that of the bench-marks at Port Dalhousie and Oswego. From an examination of gauge-records previously given, its probable error does not exceed ±0.1 foot.

Combining these results and their probable errors, we have Lake Survey bench-mark B at Oswego above mean tide New York, 252.608 feet ±0.33 foot; Lake Survey bench-mark on custom-house, Port Colborne, above mean tide New York, 585.278 feet ±0.34 foot; Lake Survey bench-mark No. 2 at Gibraltar above mean tide at New York, 585.61 feet ±0.35 foot. If we assume a probable error of ±0.1 foot in determining the mean level of Lakes Ontario and Erie from 1860 to 1875 inclusive, and in referring those levels to these bench-marks, we shall have, from results thus far obtained, mean level of Lake Ontario from 1860 to 1875 inclusive above mean tide at New York, 247.25 feet ±0.35 foot; mean level of Lake Erie from 1860 to 1875 inclusive above mean tide at New York, 573.58 feet ±0.35 foot.

C. B. C.

JUNE 21, 1876.

TABLE A.

Bench-mark.	Distance.	Date.		Elevation F. W. L.	Partial excess.	Total excess.	Mean elevation.
		F. W. L.	L. L. W.				
	Miles.			*Feet.*	*Feet.*	*Feet.*	*Feet.*
C. S. B. M.				15. 374	....	....	15. 374
B. M.	1. 25	May 15	May 28	27. 611	+0. 102	+0. 102	27. 662
B. M.	2. 25	17	29	18. 193	—0. 016	+0. 086	18. 236
3	3. 75	17	June 1	27. 578	—0. 008	+0. 078	27. 617
4	4. 75	20	2	30. 335	+0. 006	+0. 084	30. 377
5	7. 25	21	2	31. 189	+0. 001	+0. 085	31. 231
B. M.	8. 45	22	3	*31. 594	0. 000	+0. 085	31. 637
6	9. 55	22	4	50. 293	+0. 004	+0. 089	50. 337
7	10. 10	25	5	71. 069	+0. 002	+0. 091	71. 114
8	11. 60	26	7	161. 151	+0. 067	+0. 158	161. 230
9	13. 60	27	8	*195. 251	0. 000	+0. 158	195. 330
10	16. 35	28	11	194. 162	– 0. 001	+0. 157	194. 240
11	17. 60	29	14	192. 585	+0. 005	+0. 162	192. 666
12	20. 35	31	15	192. 294	—0. 030	+0. 132	192. 360
13	21. 75	June 1	16	202. 788	—0. 015	+0. 117	202. 846
14	23. 75	2	17	209. 667	—0. 016	+0. 101	209. 717
15	26. 75	4	21	218. 578	+0. 043	+0. 144	218. 650
16	29. 75	5	22	236. 449	+0. 061	+0. 205	236. 551
17	32. 25	8	23	233. 513	—0. 030	+0. 175	233. 600
18	35. 25	9	23	251. 996	+0. 040	+0. 215	252. 103
19	38. 25	10	24	252. 061	—0. 068	+0. 147	252. 134
20	40. 75	11	26	260. 042	—0. 062	+0. 085	260. 084
21	44. 50	12	29	264. 860	—0. 060	+0. 025	264. 872
22	45. 00	15	29	274. 075	—0. 010	+0. 015	274. 082
23	47. 00	16	30	273, 100	+0. 023	+0. 038	273. 119
24	50. 00	17	July 2	281. 035	—0. 001	+0. 037	281. 053
25	53. 00	21	2	303. 463	+0. 035	+0. 072	303. 499
26	57. 00	22	5	301. 470	0. 000	+0. 072	301. 506
28	63. 75	24	8	302. 037	+0. 043	+0. 115	302. 094
29	66. 25	26	8	306. 477	—0. 052	+0. 063	306. 508
30	67. 75	29	9	304. 954	—0. 024	+0. 039	304. 973
31	69. 50	30	9	307. 615	+0. 042	+0. 081	307. 655
32	70. 50	July 1	9	307. 447	+0. 050	+0. 131	307. 512
33	74. 25	2	12	312. 137	+0. 146	+0. 277	312. 275
34	77. 75	3	13	320. 495	+0. 025	+0. 302	320. 646
35	80. 75	5	14	328. 696	+0. 028	+0. 330	328. 861
36	83. 50	6	14	337. 025	+0. 074	+0. 404	337. 227
37	87. 25	8	16	344. 403	+0. 012	+0. 416	344. 611
38	90. 50	9	16	379. 235	+0. 055	+0. 471	379. 470
39	94. 00	10	19	394. 377	+0. 040	+0. 511	394. 632
40	96. 50	12	20	409. 872	+0. 023	+0. 534	410. 139
41	100. 00	13	21	419. 617	+0. 005	+0. 539	419. 886
42	104. 00	14	22	429. 607	+0. 063	+0. 602	429. 908
43	106. 75	16	27	429. 612	—0. 035	+0. 567	429 895
44	109. 75	17	28	433. 356	—0. 010	+0. 557	433. 634
45	114. 25	19	29	*433. 977	0. 000	+0. 557	434. 255
46	118. 75	20	30	433. 848	—0. 050	+0. 507	434. 101
47	120. 00	21	31	433. 430	—0. 002	+0. 505	433. 682
48	124. 25	22	Aug. 13	432. 270	—0. 051	+0. 454	432. 497
49	126. 25	23	14	433. 288	+0. 014	+0. 468	433. 522
50	129. 00	24	16	431. 677	+0. 008	+0. 476	431. 915
51	133. 75	26	17	431. 810	+0. 008	+0. 484	432. 052
52	136. 75	27	19	*392. 400	0. 000	+0. 484	392. 642
53	140. 00	28	20	*373. 652	0. 000	+0. 484	373. 894
54	144. 00	29	Sept. 22	430. 253	+0. 103	+0. 587	430. 546
55	145. 25	30	22	441. 054	+0. 028	+0. 615	441. 361
56	147. 25	31	23	417. 475	+0. 036	+0. 651	417. 800
57	150. 75	Aug. 2	25	414. 215	—0. 045	+0. 606	414. 518
58	152 25	4	25	401. 933	+0. 037	+0. 643	402. 254
59	156. 25	5	28	390. 909	+0. 058	+0. 701	391. 259
60	158. 25	6	29	379. 625	+0. 007	+0. 708	379. 979
61	160. 50	7	30	394. 838	+0. 067	+0. 775	395. 225
62	165. 00	10	Oct. 4	376. 991	+0. 051	+0. 826	377. 404
63	167. 50	11	4	405. 800	—0. 044	+0. 782	406. 191
64	171. 75	12	5	379. 858	+0. 011	+0. 793	380. 254
65	174. 25	13	6	375. 024	+0. 073	+0. 866	375. 457
66	176. 50	14	7	364. 927	—0. 004	+0. 862	365. 358
67	178. 00	16	8	333. 939	+0. 015	+0. 877	334. 377
69	185. 25	18	13	285. 225	+0. 082	+0. 959	285. 704
A (Oswego.)	187. 25	19	14	252. 132	—0. 006	+0. 953	252. 608

TABLE B.

Bench-mark.	Distance.	Date.		Elevation F. W. L.	Partial excess.	Total excess.	Mean elevation.
		F. W. L.	L. L. W.				
	Miles.						
(Port Dalhousie)...	....	Aug. 24	Oct. 16	0. 000	....	....	0. 000
" B "	....	24	16	60. 394	—0. 009	—0. 009	60. 390
1	2. 00	25	18	82. 454	+0. 021	+0. 012	82. 460
2	3. 60	26	19	209. 744	—0. 034	—0. 022	209. 733
3	6. 60	27	22	320. 033	+0. 048	+0. 026	320. 046
4	9. 60	28	23	333. 173	0. 000	+0. 026	333. 186
5	13. 10	30	25	342. 383	—0. 024	+0. 002	342. 384
6	15. 60	31	25	334. 351	—0. 006	—0. 004	334. 349
7	18. 20	Sept. 1	28	321. 755	+0. 020	+0. 016	321. 763
8	21. 80	2	29	326. 574	+0. 012	+0. 028	326. 588
Custom-house, (Port Colborne.)	24. 55						

APPENDIX G.—THE STANDARD INCH.

VALUES OF THE SPACES, DETERMINED BY LIEUT. COL. A. R. CLARKE, R. E.

ORDNANCE SURVEY OFFICE,
Southampton, June 19, 1875.

MY DEAR SIR: I send you herewith the determinations of the spaces on your standard inch. I hope you received the inch safely.

Believe me yours, very truly,

A. R. CLARKE.

General COMSTOCK.

Values of the spaces on the Standard Inch.

$$\text{Tenths: } \left(\text{unit} = \frac{\text{yard}}{1,000,000}\right)$$

$$(0.1) = \tfrac{1}{120}\,\text{F.} + 2.78 \pm 0.14$$
$$(0.2) = \tfrac{2}{120}\,\text{F.} + 7.01 \pm 0.13$$
$$(0.3) = \tfrac{3}{120}\,\text{F.} + 1.06 \pm 0.10$$
$$(0.4) = \tfrac{4}{120}\,\text{F.} - 0.47 \pm 0.12$$
$$(0.5) = \tfrac{5}{120}\,\text{F.} - 2.81 \pm 0.08$$
$$(0.6) = \tfrac{6}{120}\,\text{F.} - 5.04 \pm 0.09$$
$$(0.7) = \tfrac{7}{120}\,\text{F.} - 9.86 \pm 0.12$$
$$(0.8) = \tfrac{8}{120}\,\text{F.} - 6.69 \pm 0.12$$
$$(0.9) = \tfrac{9}{120}\,\text{F.} - 0.59 \pm 0.18$$
$$(0.10) = \tfrac{10}{120}\,\text{F.} + 4.40 \pm 0.13$$

Where F is the length at 62° of the ordnance standard foot, viz:

$$F = \tfrac{1}{3}\,Y - 0.49$$

Y being the true length of a yard, or—

$$\tfrac{1}{12}\,F = \tfrac{1}{36}\,Y - 0.04$$

The values of the 10 spaces of $\frac{1}{100}$ inch, composing (9.10), are as follows, counting from 9 towards 10:

$$\text{Space 1st} - \tfrac{1}{10}\,(9.10) + 3.64 \pm .08$$
$$\text{Space 2d} - \tfrac{1}{10}\,(9.10) - 1.44 \pm .06$$
$$\text{Space 3d} - \tfrac{1}{10}\,(9.10) - 1.59 \pm .10$$
$$\text{Space 4th} - \tfrac{1}{10}\,(9.10) + 1.50 \pm .06$$
$$\text{Space 5th} - \tfrac{1}{10}\,(9.10) + 0.52 \pm .10$$
$$\text{Space 6th} - \tfrac{1}{10}\,(9.10) + 0.36 \pm .10$$
$$\text{Space 7th} - \tfrac{1}{10}\,(9.10) - 1.31 \pm .09$$
$$\text{Space 8th} - \tfrac{1}{10}\,(9.10) + 1.06 \pm .10$$
$$\text{Space 9th} - \tfrac{1}{10}\,(9.10) - 0.22 \pm .08$$
$$\text{Space 10th} - \tfrac{1}{10}\,(9.10) - 2.53 \pm 06$$

N. B.—The probable error of the space (9.10) is this:

$$(9.10) = \tfrac{1}{120}\,\text{F.} + 4.99 \pm 0.13$$

Total number of observations, 1,032.

A. R. CLARKE, *Lieut. Col., R. E.*

APPENDIX H.—REDUCTION OF WATER-LEVEL OBSERVATIONS.

REPORT OF MR. O. B. WHEELER, ASSISTANT ENGINEER.

OFFICE UNITED STATES LAKE SURVEY,
Detroit, Mich., June 13, 1876.

SIR: I have the honor to submit the following report on a reduction of observations made since 1859, to determine the fluctuations of the surfaces of the lakes.

In June, 1859, a systematic series of observations of water-levels at several places on each lake was commenced by Captain Meade. The results have been published from time to time in the Lake Survey Reports. A re-reduction from the original observations of the entire series, from June, 1859, to June, 1876, is here given, together with observations made at Oswego, N. Y., furnished by Maj. J. M. Wilson, Corps of Engineers, U. S. A.; observations at Toronto, Ontario, furnished by Prof. G. T. Kingston, superintendent meteorological service, Toronto, Ontario; observations at Port Colborne, Ontario, furnished by E. V. Bodwell, superintendent Welland Canal; and observations at Chicago, Ill., furnished by William H. Clarke, assistant city engineer, Chicago, Ill.

The Lake Survey stations at which the observations have been most continuous, and for which curves have been platted, are: Charlotte, Sacket's Harbor, and Fort Niagara, on Lake Ontario; Cleveland, Erie, and Monroe, on Lake Erie; Milwaukee, Point aux Barques, and Port Austin, on Lakes Michigan and Huron; and Sault Ste. Marie and Marquette, on Lake Superior.

An endeavor has been made to check each of the principal curves by other curves on the same lake, and, since the Superior and Detroit curves would stand without a check, these are not platted.

The method of observation at the several Lake Survey stations is at present as follows: A convenient fixed point, called the zero of gauge, is chosen. The distance of the surface of the water from this zero is measured with a rod graduated to hundredths of a foot. These measurements are taken three times a day, viz, at 7 a. m., 1 p. m., and 7 p. m., local time. The zero of gauge at each station is connected with at least two permanent bench-marks, and levels are run each season to see if any change in the position of the zero has taken place. As an additional precaution, "a check-point" is established at each station, from which readings are taken twice each month in the same way as from the zero of gauge. This serves to detect any change in the position of the zero, and if any change in its position should be found by the leveling, the check-point readings will show when the change occurred.

Prior to 1875, instead of a simple graduated rod for measuring the distance of the water below the zero of gauge, a float and rod were used. The float was cylindrical, with conical ends, and the rod was inserted in the upper end. The apparatus was so balanced that, when placed vertically in the water, it floated with the zero of graduation at the surface. The rod, moving up and down past the zero of gauge, indicated at once the depth of water below this zero. These floats were abandoned on account of the trouble of keeping them in perfect order.

Between 1860 and 1871 but little attention was paid to the checking of zeros of gauges and bench-marks. Since 1871 it has been carefully attended to, and levels have been run each year.

Each observer, at the end of the month, sends his record to the office here, where the reductions are made.

In the reports of these reductions published before 1875 the observations are given as reduced to what is known as the high water of 1838. This high water having been observed only at Cleveland and Milwaukee was unsatisfactory for the other lakes, and in this re-reduction an arbitrary plane has been assumed for each lake. These planes are referred to permanent bench-marks, and are taken so as to coincide, as nearly as can be ascertained, with the high water of 1838.

In reducing the records the daily means are first found, and thence the monthly mean. This latter is reduced to the plane of reference by applying the appropriate number as explained in the list of bench-marks and zeros of gauges given below. The quantities found in this way form the tables appended to this report, and from these tables the annual water-level curves have been platted.

The record of observations is not continuous at all of the stations. The places where the breaks occur can readily be seen from the curves and also from the tables.

The annual water-level curves are represented on Plates I to IV. The scale of elevation is 1 inch to the foot. For Lake Ontario, curves representing the fluctuations at five stations are given. The Charlotte curve is made the principal one. For Lake Erie four curves are given. Cleveland is represented as the main one. At Erie no winter observations are made, and hence the numerous breaks in that curve.

For Lakes Huron and Michigan four curves are given. Milwaukee is represented as the main one. It is checked at intervals for most of its length by the others. But

two curves are given for Lake Superior, that at Sault Ste. Marie being the more prominent.

An inspection of the curves will show that:

1. Lakes Huron and Michigan run together so closely that they may be regarded as one lake.

2. On Lake Ontario high water is most likely to occur in May or June, on Lake Erie in June or May, on Lake Huron in July and August, and on Lake Superior in August or September.

3. On Lakes Erie and Ontario low water occurs generally in February, on Lake Huron in February, and on Lake Superior in March.

4. Lakes Huron and Erie correspond much more nearly than Lakes Erie and Ontario.

5. Lake Superior fluctuates less than any of the others.

6. The extreme fluctuations between high and low waters in different years are greater on Lake Ontario than on Lakes Erie and Huron. On Lake Ontario high waters in different years may differ in round numbers by 3 feet; on Lakes Erie and Huron by 2 feet.

7. Lakes Huron, Erie, and Ontario are so connected that high or low water in one in any year indicates high or low water in all. Lake Superior stands alone.

8. The extreme range in monthly means from the lowest water to the highest for a period of 17 years is approximately, for Lake Ontario, 4½ feet, for Lakes Erie, Huron, and Michigan, 3½ feet.

LAKE ONTARIO.

Reference plane.—The plane of reference of water-level is a horizontal plane 34.19 feet below the upper side of the water-table of the light-house, at the south-southeast angle, east of the south window, Charlotte, N. Y.

Mean level.—The mean level of Lake Ontario, as observed at Charlotte, from January 1, 1860, to December 31, 1875, inclusive, is 36.62 feet below the above bench-mark.

Charlotte, N. Y.

Bench-marks.—The bench-marks at Charlotte are:

(1.) The upper side of the water-table of the light-house at the south-southeast angle, east of the south window. It is 34.19 feet above the plane of reference.

(2.) A bench-mark [B × M] on the top of the circular wall of the railroad turn-table, southwest part of the wall. It is 4.40 feet above the plane of reference.

Zero of gauge.—The zero of gauge is the top of a copper bolt (½ inch in diameter) leaded into the stone pier of the railroad-bridge. It is 0.48 foot below the plane of reference, and 1.52 feet lower than the zero (December, 1871—March, 1875) used in comparison with the other stations.

Check-point.—The fixed point for check-measurements is the head of a wrought spike driven into the new crib-wharf just above the new railroad-bridge. It is 0.78 foot below the plane of reference.

Sacket's Harbor, N. Y.

Assuming that the surface of the lake was level during the months of June, July, and August, 1874, by comparing the observations at Charlotte and Sacket's Harbor for these months it is found that the zero (December, 1871—March, 1875) at Charlotte was 2.22 feet below that at Sacket's Harbor. Hence the Sacket's Harbor zero was 3.41 feet above the plane of reference.

Bench-marks.—The bench-marks at Sacket's Harbor, N. Y., are:

(1.) A cross on the solid rock between the sidewalk and the water, N. 2° E. from the northwest corner of the Masonic temple, and 96½ feet distant. It is 2.98 feet above plane of reference.

(2.) The upper side at the outer edge of the water-table at the northeast corner of the stone Masonic temple. It is 15.64 feet above the plane of reference.

Zero of gauge.—The zero of gauge is the slot of a 3-inch screw sunk in the head of a timber fastened to a piece of crib-work near Hall's dock. It is 0.28 foot above the plane of reference, and 3.13 feet lower than the zero (May, 1872—December, 1874) used in comparison with Charlottte.

Check-point.—The fixed point for check-measurements is the intersection of two perpendicular lines in the head of a 7-inch screw-bolt leaded into the natural rock, situated about ⅝ mile down the bay from the United States naval quarters. It is 1.31 feet above the plane of reference.

Oswego, N. Y.

Assuming that the surface of the lake was level during the months of June, July, and August, 1874, by comparing the observations at Charlotte and Oswego for these months it is found that the zero of gauge at Oswego was 5.95 feet below that of Char

lotte, (December, 1871–March, 1875.) Hence the Oswego zero of gauge was 4.76 feet below the plane of reference.

Bench-marks.—(A.) The top of iron bolt in masonry of Government pier, 0.5 feet from east face of pier, 3.5 feet north of northwest corner of United States engineer's store-house, about 10 feet west of tide-gauge on United States Reservation, marked "B o M." It is 2.99 feet above plane of reference.

(B.) The highest point of stone post, flush with ground, marked U. S., in prolongation south of west face of Government (stone) pier, 8 feet south from end of masonry of pier, 28 feet west from southwest corner of United States engineer's store-house. This stone marks the southwest corner of the boundary of the United States reservation. It is 3.50 feet above the plane of reference.

(C.) A cross cut in stone, 3 feet from southwest corner, in third course of masonry of west side of shop of dry-dock of marine railway, on corner of Lake and Second streets. Bench-mark marked "U. S." It is 13.07 feet above plane of reference.

Zero of gauge.—The water-gauge is an iron plate graduated to tenths of a foot, which is fastened to a pile, so that its zero is at extreme low-water level. The readings show the height of surface of water above this zero.

Port Dalhousie, Ontario.

Assuming that the surface of the lake was level during the months of June, July, and August, 1875, by comparing the observations at Charlotte and Port Dalhousie for these months it is found that the zero of gauge at Port Dalhousie was 9.37 feet higher than that at Charlotte. Hence the Port Dalhousie zero of gauge is 9.04 feet above the plane of reference.

Bench-marks.—(A.) Top of stone post buried under sidewalk corner of Canal and Lock streets, 10½ feet from southeast corner of "Wood House," on perpendicular to east side of "Wood House," (toward canal,) about 110 feet west of heel-post of west gate of north end of canal-lock. It is 15.02 feet above plane of reference.

(B.) Edge of square cut in top course of masonry in north recess, in east wall of canal 20 feet north of northeast gate of lock, one foot below upper surface of coping.

(C.) Cross cut into stone foundation of collector's office, third course of stones from top, north side, 1.4 feet from northwest corner. It is 9.21 feet above the plane of reference.

Zero of gauge.—This bench-mark is the zero of gauge.

LAKE ERIE.

Reference plane.—The plane of reference of water-levels is the high water of 1838 as observed at Cleveland, Ohio. It is a horizontal plane 6.30 feet below the bench-mark (×) on the top of the coping of the lock of the Ohio Canal, between Merwin street and the Cuyahoga River, Cleveland, Ohio.

Mean level.—The mean level of Lake Erie, as observed at Cleveland, Ohio, from January 1, 1860, to December 31, 1875, inclusive, is 8.61 feet below the above bench-mark and 4.94 feet below the cross (×) of the city engineer, on the northeast corner of the Johnson Block, southwest corner of Front and East River streets.

Cleveland, Ohio.

Bench-marks.—The bench-marks at Cleveland are:

(1.) A mark (B×M) on the top of the west wall of the Ohio Canal, at the connection of the canal with the river. It is 6.30 feet above the plane of reference.

(2.) A cross (×) on the water-table northeast corner of Johnson House block, southwest corner of Front and East River streets. It is 2.63 feet above the plane of reference.

(3.) A cross (×) on the stone water-table southwest corner of brick block, northeast corner of River and Superior streets. It is 19.62 feet above the plane of reference.

Zero of gauge.—The zero of gauge is a point 0.6 feet above the upper surface of one of the outer timbers of the dock at the foot of Superior street. It is 2.94 feet above the plane of reference.

Check-point.—The check-point is the upper surface of a 6-inch spike driven behind the fender to the east pier of Lake Shore and Michigan Southern Railroad bridge, north side of bridge. It is 2.53 above plane of reference.

Erie, Pa.

Assuming that the surface of the lake was level during the months of June, July, and August, 1874, it is found, by comparison of observations during these months, that the zero at Erie (June, 1873–October, 1874) was 0.62 feet above that at Cleveland, or the Erie zero was then 3.52 feet above the plane of reference.

Bench-marks.—The bench-marks at Erie are:

(1.) The highest point of a stone post 336 feet distant from the nearest point of the

pier on which the gauge is situated, and on the north side. The northeast corner of the light-keeper's dwelling is 228 feet distant, and bears south 68° east. It is 0.43 feet above plane of reference.

(2.) A mark (×) on the beacon pier, being on the southwest corner of the cut-stone foundation of the beacon light. It is 7.92 feet above the plane of reference.

(3.) A nail-head driven into the surface-plank of the beacon pier, 4½ feet from the northwest corner. The letters B. M. are cut near it. It is 6.69 feet above the plane of reference.

Zero of gauge.—The upper edge of a bolt-head 1 inch square, driven into the boat-house pier, south side, east of boat-house, and 6 feet distant from southeast end of pier. It is 0.64 foot above the plane of reference.

Check-point.—The check-point is the under edge of a bolt-head 1 inch square, driven into the break-water pier, east side, and distant 45 feet from the north-channel pier. It is 1.04 feet above plane of reference.

Port Colborne, Ontario.

Assuming that the surface of the lake was level during the months of June, July, and August, 1875, by comparing the observations at Cleveland and Port Colborne for these months it is found that the zero of gauge at Port Colborne is 2.62 feet higher than that at Cleveland. Hence the Port Colborne zero is 5.56 feet above the plane of reference.

Bench-marks.—(1.) B. M. on custom-house, an iron plug set in stone foundation, southwest corner, west side of custom-house, about 4 feet from corner. It is 9.42 feet above the plane of reference.

(2.) An iron bolt in east end of stone window-sill in basement of steeple, south side of Baptist church, on northwest corner of Clarence and Catherine streets. It is 5.22 feet above the plane of reference.

(3.) An iron plug in lower tier of stone in stone foundation, in south side, street-front, (Charlotte street,) east of entrance to Church of England. It is 3.77 feet above plane of reference.

Zero of gauge.—The zero of gauge is an iron bolt set into the top course of stones in recess, south extension of lock, west side of canal, just above swing-bridge, close to the point where old measures have been taken. It is 20.14 feet above lower (south) miter-sill. The zero is 5.56 feet above plane of reference.

Rockwood, Mich.

Assuming that the surface of the lake was level during the months of June, July, and August, 1875, by comparing the observations at Cleveland and Rockwood for these months it is found that the zero of gauge at Rockwood is 1.91 feet below that at Cleveland. Hence the Rockwood zero is 1.03 feet above the plane of reference.

Bench marks.—The bench-marks for the Rockwood gauge are:

(1.) A small cross (×) on the stone window-sill of the south window, on the west side of the brick house of Mr. Craig, corner Farnsworth and Adams streets, Gibraltar, Mich. It is 11.70 feet above the plane of reference.

(2.) The southeast corner of the stone door-sill of the door in the southeast angle of the light-house at Gibraltar, Mich. It is 9.71 feet above the plane of reference.

(3.) The highest point of a large rock 120 feet southeast of the southeast corner of log house. It is 0.84 feet below the plane of reference.

Zero of gauge.—The zero of gauge is the highest point of a spike driven into the post supporting the runway of the ice-house on the Story farm. It is 1.03 feet above the plane of reference.

Detroit, Mich.

Bench-mark.—A cross (×) on the new light-house depot, 8.2 feet below the outer edge of the water-table in the southern projection of the southeast door, on the cut-stone foundation.

Zero of gauge.—The zero of gauge is the highest point of the square head of an 8-inch bolt driven into the timber supporting the planking of the pier. It is on the Government dock, west side, 18 feet from the junction of the pier with the bulk-head. It is 5.16 feet below the bench-mark, and 2 feet above the plane of reference adopted for the Detroit River at Detroit.

Check-point.—The check-point is the highest point of a similar spike driven into the bulk-head southeast of the light-house depot, and 72 feet east of the pier. It is 5.89 feet below the bench-mark.

LAKES MICHIGAN AND HURON.

Reference plane.—The plane of reference of water-levels is the high water of 1838, as

observed at Milwaukee, Wis. It is a horizontal plane 8.33 feet below the bench-mark on Dr. I. A. Lapham's house, Poplar street, Milwaukee.

Mean level.—The mean level of Lake Michigan, as observed at Milwaukee from January 1, 1860, to December 31, 1875, inclusive, is 11.39 feet below bench-mark on Dr. Lapham's house.

Milwaukee, Wis.

Bench-marks.—(1.) The bench-mark on Dr. Lapham's house is the top of the brick water-table east side of main door. The part exposed is 4 inches by 1 inch.

(2.) Stone monument in court-house square, near the southeast corner thereof, in the seventh ward. It is 51.36 feet above the plane of reference.

(3.) Stone monument on sidewalk at southeast corner of Eighth and Chestnut streets, second ward. It is 49.27 feet above the plane of reference.

(4.) The highest point of the stone water-table at the corner of the building, Ludington's block, northwest corner of East Water and Wisconsin streets. It is 9.61 above the plane of reference.

Zero of gauge.—The zero of gauge is the highest point of a nail-head driven into a large pile supporting platform at the corner of the railroad warehouse, foot of Poplar street, south side of street. It is 1 foot above the plane of reference.

Check-point.—The check-point is on the north side of the center pier of the swing-bridge over the river, between Chestnut and Division streets. It is the top of a copper bolt 1 inch in diameter, leaded into the stone. This point is 1.86 feet above the plane of reference.

Escanaba, Mich.

Assuming that the surface of the lake was level during the months of June, July, and August, 1874, by comparing the observations at Milwaukee and Escanaba for these months it is found that the zero (May, 1874–July, 1875) at Escanaba was 3.39 feet above the zero at Milwaukee. Hence the Escanaba zero was 4.39 feet above the plane of reference.

Bench-marks.—The bench-marks at Escanaba are:

(1.) The top of the water-table of the large brick building of S. Adler, on the northwest corner of Ludington street and Douseman avenue, on the southeast corner of the building. It is 8.64 feet above the plane of reference.

(2.) The top of the water-sill of the Escanaba light-house, at the north side of the front door, against the brick wall. It is 3.16 feet above the plane of reference.

Zero of gauge.—The zero of gauge is the highest point of the head of an 8-inch spike driven into a beam of the main dock of the Goodrich Transportation Company, west side, and at junction of bridge with main dock. It is 0.78 feet above the plane of reference.

Check-point.—The check-point is the highest point of the square head of an 8-inch spike driven into a timber of Oliver's dock, foot of Smith street, on west side of dock, near junction of main dock and bridge. It is 1.12 feet above the plane of reference.

Port Austin, Mich.

Assuming that the surfaces of Lakes Huron and Michigan were each level, and of the same level during the months of June, July, and August, 1874, by comparing the observations at Milwaukee and Port Austin for these months it is found that the zero at Port Austin is 6.19 feet above the plane of reference for Lake Michigan.

Bench-mark.—The head of a 6-inch bolt leaded into the rock, 13 feet southwest of the gauge. It is 6.19 feet above the plane of reference.

Zero of gauge.—The reading point is the upper edge of a board nailed to one of the studs of the gauge-house. The zero is an imaginary point, 4 feet below this, and on the same level as the bench-mark mentioned above.

Check-point.—The check-point is the top of the head of a bolt leaded into the rock, (0 feet northwest of gauge-house. It is 1.23 feet below the plane of reference.

Lakeport, Mich.

Assuming that the surfaces of Lakes Huron and Michigan were each level, and of the same level during the months of June, July, and August, 1875, by comparing the observations at Milwaukee and Lakeport for these months it is found that the Lakeport zero is 3.38 feet above the plane of reference for Lake Michigan.

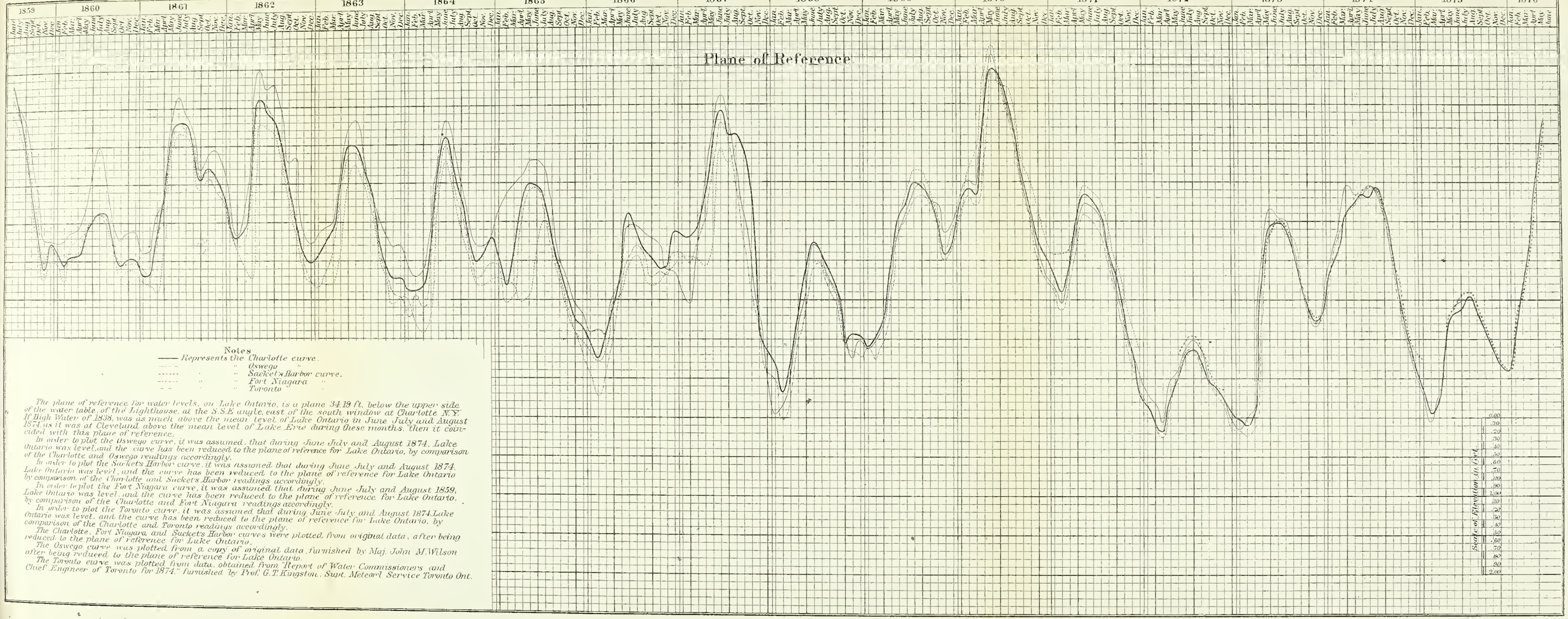
Bench-marks.—(1.) A spike driven into a cedar post supporting the steam grist-mill of John Cole, post being on north side of mill, and 12 feet from northwest corner. It is 9.78 feet above the plane of reference.

(2.) A cross (×) cut in the stone on the east side of the engine-house of the grist-mill, and at the southeast corner. It is 6.52 feet above the plane of reference.

(3.) The highest point of the top stone of the foundation of the milk-house of Mr.

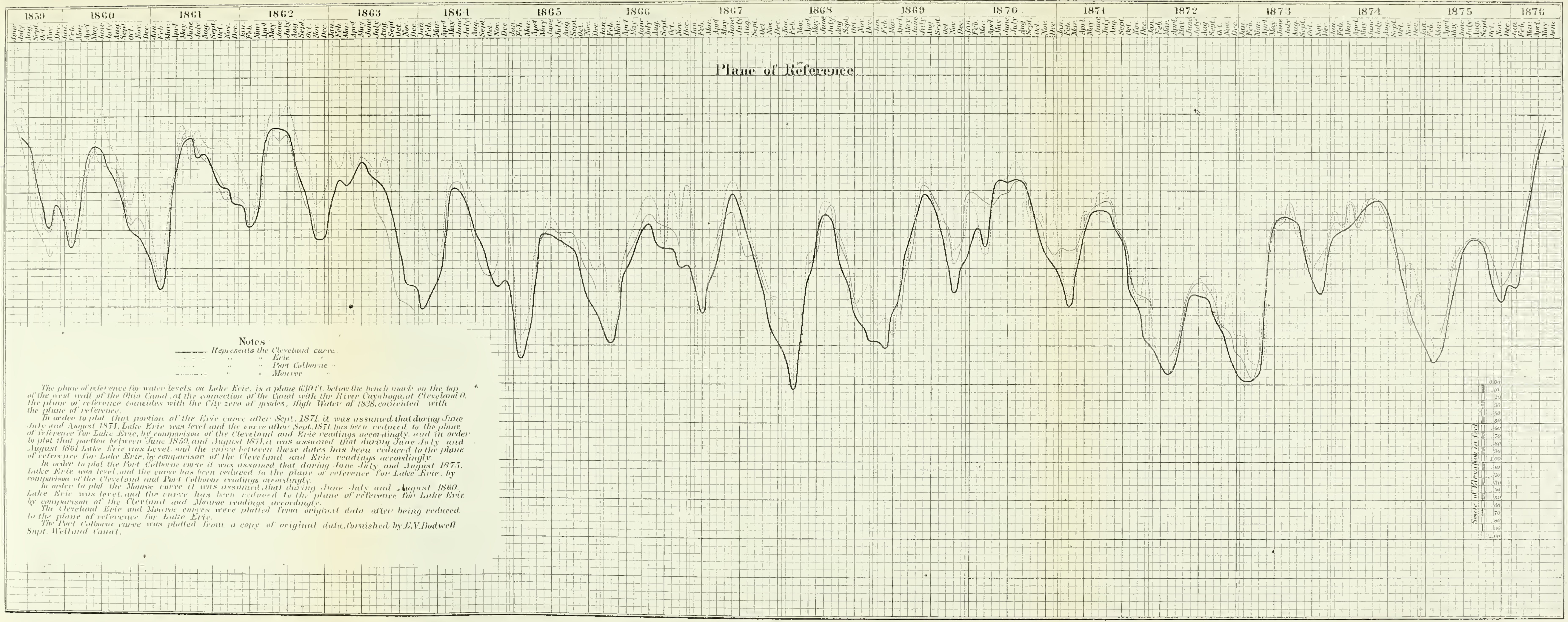
Annual Water Level Curves on Lake Ontario.

Plate I.



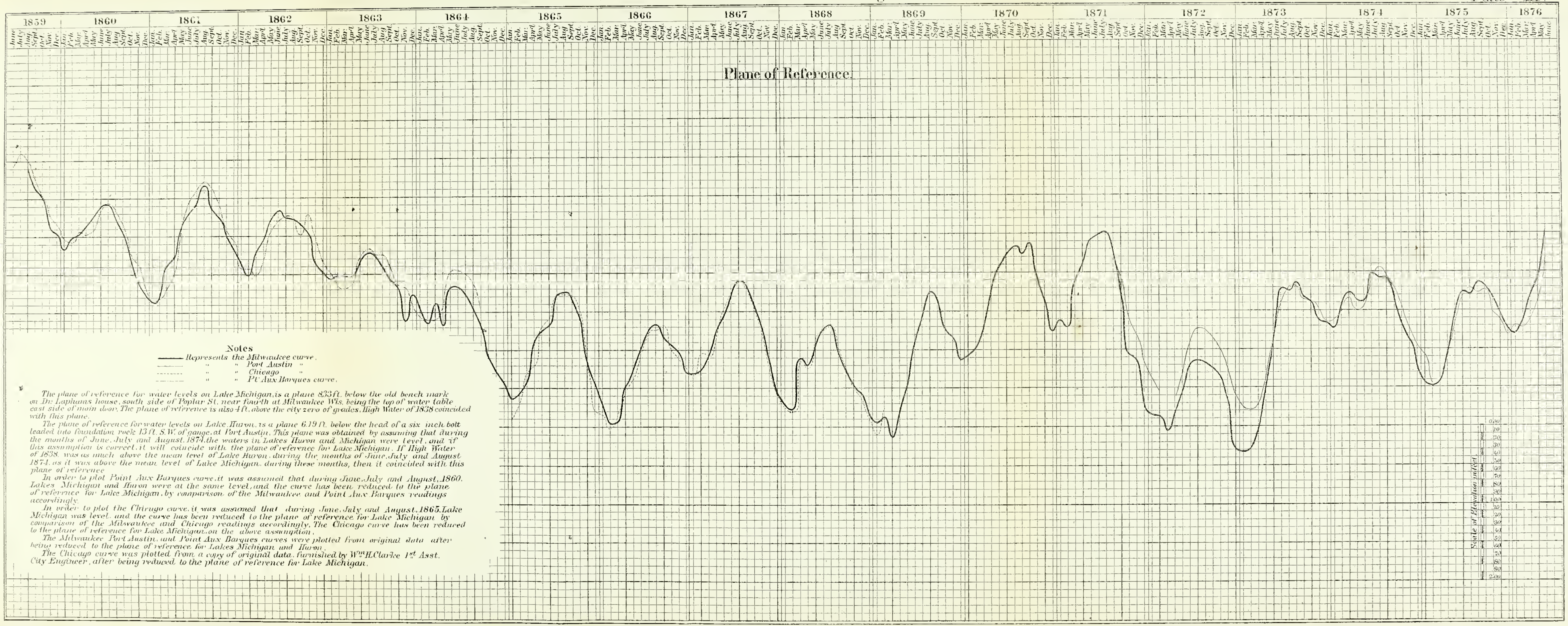
Annual Water Level Curves on Lake Erie.

Plate 11



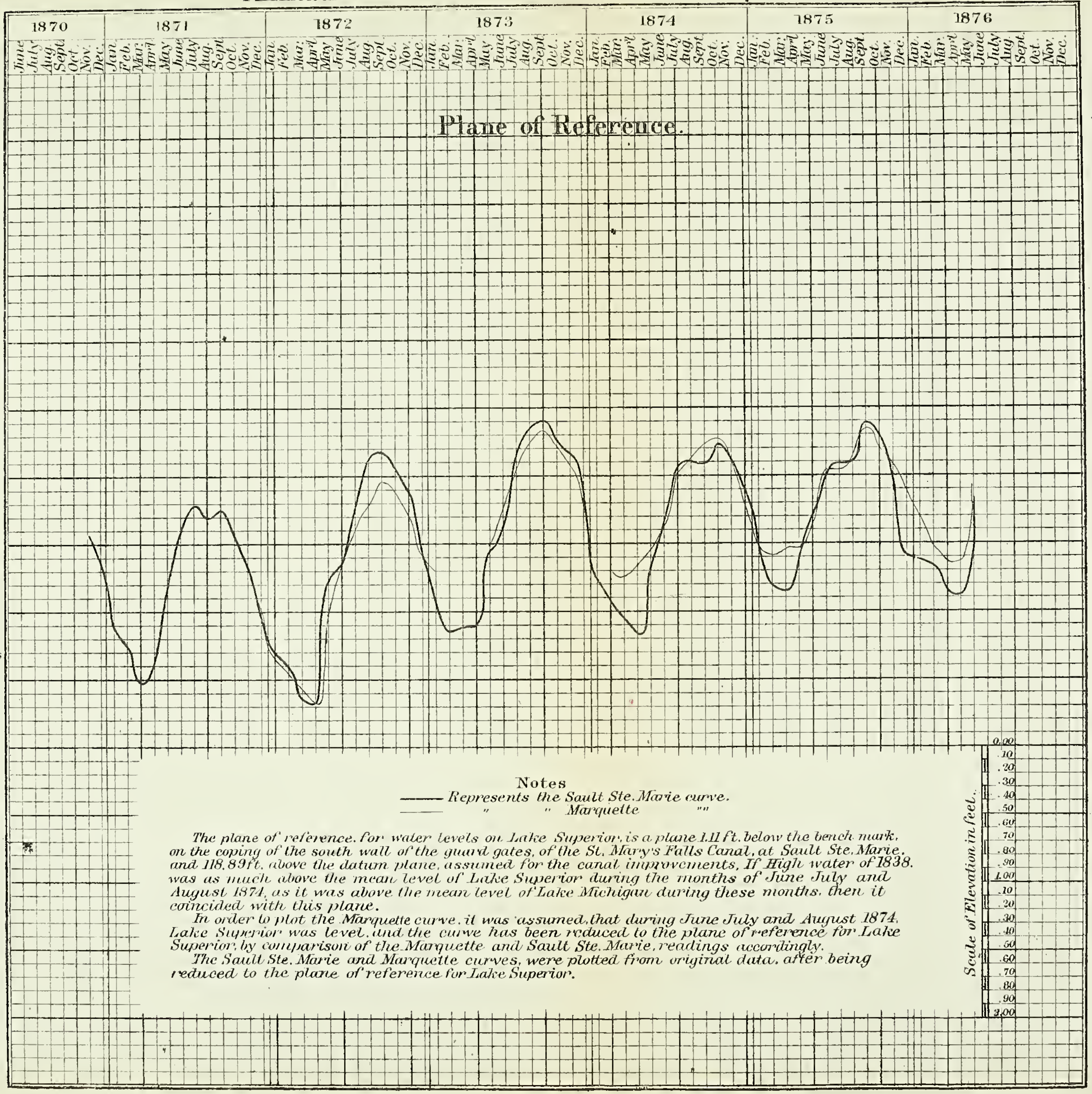
Annual Water Level Curves on Lakes Michigan and Huron.

Plate III.



Annual Water Level Curves on Lake Superior.

Plate IV.



Cole, Second street, at the southeast corner of the building. It is 14.31 feet above the plane of reference.

Zero of gauge.—The spike from which measurements are made is driven into the west side of the west cross-piece of two cross-pieces resting on the second row of piles supporting the road leading to the only dock in the place, (north side of road.) It is 3.38 feet above the plane of reference.

LAKE SUPERIOR.

Reference plane.—The plane of reference of water-levels is a horizontal plane 1.11 feet below the B□M on the coping of the south wall of the guard-gates of St. Mary's Canal, Sault Ste. Marie, and 118.89 feet above the datum-plane assumed for the canal improvement. If the high water of 1838 was as much above the mean level of the lake in June, July, and August, 1874, as it was at Milwaukee above the mean level of Lake Michigan in June, July, and August, 1874, then the high water of 1838 coincided with this plane.

Sault Ste. Marie.

Bench-marks.—(1.) A cross on a stone near the Indian agency. It is 15.56 feet below the plane of reference.

(2.) A bench-mark (B□M) on the coping of the south wall of the guard-gates of St. Mary's Canal. It is at the upper-gate recess, 2.5 feet from the foot of the gate-tower, and 0.5 feet from the face of the wall. It is 1.11 feet above the plane of reference.

Zero of gauge.—The zero of gauge is 0.37 feet below bench-mark, (2,) and hence is 0.74 feet above the plane of reference.

Marquette.

Assuming that the surface of the lake was level during the months of June, July, and August, 1874, it is found, by comparison of observations during these months, that the zero (February, 1874–July, 1875) is 1.06 above that at Sault Ste. Marie. Hence the Marquette zero is 1.80 feet above the plane of reference.

Bench-marks.—(1.) The southeast corner of the top of the foundation-stone of Grace Furnace. It is 5.17 feet above the plane of reference.

(2.) A bench-mark on the window-sill of the Marquette City water-works. It is on the center window, west side of building and north side of window. It is 4.67 feet above the plane of reference.

(3.) For convenience of reference a bench-mark (B×M) was set on the east side of the water-works building. It is on the sill of the north window on that side, and 6 inches from the north end of the sill. It is 4.58 feet above the plane of reference.

Zero of gauge.—The zero of gauge (July, 1875–1876) is the top of the head of a 5-inch iron spike driven into the center of the top timber of the merchandise-pier of the Marquette, Houghton and Ontonagon Railroad, north side, and near shore-end of pier. It is 2.05 feet above the plane of reference.

Check-point.—The fixed point for check measurements is on the new Government breakwater. It is the highest point of the head of a 5-inch bolt driven into the timber, about 100 feet distant from the water-works, and on the west side of the pier. It is 2.12 feet above the plane of reference.

The data for this report are to be found in office reports Nos. 291, 466, 469, 485, and 486.

Very respectfully, your obedient servant,

O. B. WHEELER,
Assistant Engineer.

General C. B. COMSTOCK,
Superintendent United States Lake Survey.

TABLES SHOWING MONTHLY AND YEARLY MEANS OF WATER-LEVELS FOR THE SEVERAL STATIONS. (OFFICE REPORT No. 486.)

CHARLOTTE.

Mean monthly water-level, in feet and decimals, below plane of reference for Lake Ontario.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.
1859	......	......	......	......	......	0.15	0.46	0.96	1.66	2.13	2.62	2.29	......
1860	2.40	2.57	2.46	2.44	2.20	2.01	1.89	1.90	2.31	2.57	2.49	2.48	2.31
1861	2.70	2.69	2.25	1.71	0.94	0.70	0.69	0.98	1.44	1.29	1.38	1.58	1.53
1862	1.94	2.20	2.09	1.23	0.40	0.55	0.66	0.99	1.52	2.02	2.39	2.53	1.54
1863	2.46	2.27	2.10	1.51	1.01	1.01	1.25	1.56	2.11	2.54	2.73	2.72	1.94
1864	2.88	2.90	2.83	2.29	1.24	0.91	1.31	1.69	2.22	2.51	2.42	2.20	2.12
1865	2.47	2.81	2.40	1.77	1.51	1.54	1.74	2.23	2.59	2.94	3.26	3.34	2.38
1866	3.53	3.76	3.45	3.10	2.64	1.90	2.13	2.35	2.49	2.61	2.59	2.13	2.72
1867	2.19	2.21	2.08	1.67	0.88	0.58	0.90	0.89	1.09	1.63	3.42	3.64	1.77
1868	3.82	4.18	3.82	3.16	2.63	2.28	2.41	2.62	2.85	3.55	3.44	3.46	3.19
1869	3.60	3.47	3.28	2.54	1.95	1.78	1.51	1.56	1.71	2.01	2.42	2.27	2.34
1870	1.74	1.59	1.66	0.63	-0.05	0.17	0.44	0.89	1.49	1.84	2.26	2.46	1.26
1871	2.68	2.90	2.61	1.95	1.66	1.73	1.90	2.34	2.68	3.25	3.63	4.20	2.63
1872	4.35	4.55	4.68	4.26	4.02	3.70	3.64	3.79	4.04	4.14	4.25	4.44	4.16
1873	4.51	4.60	4.43	2.75	2.07	2.02	2.08	2.32	2.76	3.12	3.28	3.15	3.09
1874	2.68	2.34	1.90	1.79	1.66	1.70	1.59	1.84	2.34	2.95	3.48	3.78	2.34
1875	4.13	4.46	4.30	3.52	3.17	3.12	2.97	3.15	3.38	3.63	3.81	3.91	3.63
1876	3.50	2.87	2.28	1.36	0.68	......	......	......	......	......	......	......	......

OSWEGO.

Mean monthly water-level, in feet and decimals, below plane of reference for Lake Ontario.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.
1859	......	......	......	......	......	0.12	0.46	0.64	1.15	1.64	2.23	2.24	......
1860	2.27	2.23	2.13	2.09	1.85	1.38	1.01	1.59	2.04	2.23	2.14	2.13	1.92
1861	2.40	2.39	1.90	1.75	0.79	0.36	0.59	0.79	1.30	1.13	1.06	1.27	1.31
1862	1.72	2.18	1.81	0.96	0.01	0.27	0.21	0.55	1.23	1.18	2.12	2.28	1.21
1863	2.16	2.07	2.00	1.36	0.80	0.69	1.06	1.59	1.91	2.16	2.32	2.30	1.70
1864	2.58	2.71	2.64	2.12	1.14	0.70	1.00	1.48	1.97	2.30	2.31	2.21	1.95
1865	1.84	1.66	1.51	1.42	1.23	1.22	1.30	1.86	2.50	2.77	3.05	3.19	1.96
1866	3.42	3.39	3.44	2.95	2.76	2.07	2.06	2.14	2.23	2.30	2.62	2.66	2.67
1867	2.89	3.06	2.40	1.42	0.80	0.39	0.74	1.33	1.87	2.45	3.20	3.97	2.04
1868	4.46	4.36	4.09	3.37	2.91	2.30	2.43	2.72	2.88	3.43	3.74	3.52	3.35
1869	3.62	3.52	3.36	2.80	2.14	1.90	1.59	1.51	1.72	1.78	2.15	2.02	2.34
1870	1.69	1.49	1.54	0.67	-0.11	0.21	0.53	0.90	1.57	1.90	2.40	2.70	1.29
1871	2.82	3.03	2.68	2.16	1.78	1.81	1.91	2.36	2.81	3.31	3.66	3.96	2.69
1872	4.21	4.31	4.56	4.01	3.91	3.66	3.51	3.66	4.01	4.16	4.26	4.56	4.07
1873	4.66	4.51	4.41	2.44	1.86	1.96	1.98	2.31	2.76	3.13	3.36	3.09	3.04
1874	2.48	2.11	1.56	1.66	1.66	1.56	1.66	1.91	2.53	2.96	3.56	3.91	2.30
1875	4.18	4.56	4.24	......	3.11	3.03	2.95	......	......	......	......	......	......

FORT NIAGARA.

Mean monthly water-level, in feet and decimals, below plane of reference for Lake Ontario.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.
1859	......	......	......	......	......	0.56	0.79	1.08	1.73	2.32	2.74	2.52	......
1860	2.55	2.77	2.31	2.21	2.13	2.01	1.93	2.04	2.38	2.70	2.63	2.63	2.36
1861	2.79	2.82	2.91	2.39	1.11	0.84	0.87	1.09	1.58	1.44	1.58	1.70	1.76
1862	2.04	2.35	2.59	2.73	0.72	0.79	0.85	1.29	1.75	2.16	2.62	2.79	1.89
1863	2.79	2.80	2.81	2.39	1.51	1.28	1.52	1.82	2.37	2.71	3.05	2.97	2.34
1864	3.00	3.30	3.42	3.15	1.75	1.22	1.62	2.06	2.44	2.80	2.81	2.76	2.53
1865	2.75	2.77	2.82	3.03	2.99	2.40	2.00	2.22	2.69	3.17	3.41	3.57	2.82
1866	3.69	3.79	3.67	3.07	2.92	2.59	2.45	2.67	2.82	2.79	2.67	2.58	2.98
1867	2.46	2.45	2.49	2.58	2.24	1.08	1.26	1.02	(*)	......	......	......	......
1868	......	......	......	......	......	†2.52	2.52	2.72	2.94	3.43	......	......	......
1869	‡3.28	3.34	3.45	3.40	1.96	1.63	1.36	1.38	1.59	1.91	2.35	2.08	......
1870	1.96	1.36	1.12	0.11	-0.25	0.26	0.29	0.62	1.27	1.49	1.87	2.15	1.02
1871	2.41	2.41	2.38	1.96	1.54	1.62	1.75	2.08	2.54	2.88	3.31	3.61	2.37

* September, October, November, and December, 1867, January, February, March, April, and May, 1868, observer could not read the rod.
† June, 1868, new rod put in.
‡ January, February, March, and April, 1869, were not platted, being evidently read from the ice.

SACKET'S HARBOR.

Mean monthly water-level, in feet and decimals, below plane of reference for Lake Ontario.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.
1872	......	......	......	......	3.71	3.54	3.46	3.64	3.89	4.11	4.16	......	......
1873	......	......	......	2.50	2.19	1.99	2.07	2.37	2.70	3.12	3.23	3.19	......
1874	......	......	......	1.72	1.65	1.57	1.60	1.91	2.49	2.78	3.45	3.68	......
1875	3.76	......	......	3.40	3.14	2.97	2.91	3.09	3.32	3.60	3.76	3.91	......
1876	3.49	2.91	2.32	1.41	0.76	......	......	......	......	......	......	......	......

TORONTO.

Mean monthly water-level, in feet and decimals, below plane of reference for Lake Ontario.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.
1854	2.16	2.08	2.00	1.81	1.27	0.86	0.98	1.56	1.84	2.38	2.94	3.08	1.91
1855	3.16	3.27	3.43	3.31	2.45	2.14	1.60	1.46	1.66	1.77	1.98	1.92	2.35
1856	2.18	2.33	2.41	2.12	1.43	1.23	1.32	1.70	2.06	2.45	2.95	3.22	2.12
1857	3.52	3.41	2.85	2.37	1.37	0.80	0.35	0.38	0.58	1.06	1.10	0.72	1.54
1858	1.24	1.33	1.80	1.47	1.29	0.54	0.28	0.45	0.88	1.42	1.75	2.10	1.21
1859	2.07	2.00	1.89	0.98	0.37	0.37	0.60	0.86	1.49	1.97	2.52	2.31	1.45
1860	2.43	2.42	2.49	2.39	2.14	1.96	1.90	1.95	2.29	2.57	2.57	2.54	2.30
1861	2.61	2.71	2.33	1.71	1.06	0.71	0.80	0.91	1.41	1.34	1.35	1.58	1.54
1862	1.95	2.33	2.24	1.40	0.41	0.48	0.68	1.03	1.52	2.06	2.45	2.78	1.61
1863	2.84	2.64	2.37	1.76	1.12	1.11	1.28	1.68	2.20	2.63	2.90	2.97	2.13
1864	3.22	2.97	3.10	2.56	1.52	1.03	1.47	1.88	2.32	2.74	2.66	2.54	2.33
1865	2.55	3.04	2.97	1.93	1.60	1.57	1.92	2.34	2.75	3.12	3.41	3.66	2.57
1866	3.95	4.24	3.93	3.50	2.86	2.49	2.32	2.43	2.71	2.67	2.69	2.41	3.02
1867	2.42	2.53	2.33	1.96	1.29	0.74	0.98	1.53	2.24	2.90	3.39	3.91	2.19
1868	4.02	4.52	4.20	3.55	3.16	2.58	2.52	2.87	3.03	3.53	3.67	3.71	3.45
1869	3.62	3.76	3.56	2.93	2.11	1.97	1.75	1.68	1.76	2.01	2.50	2.35	2.50
1870	1.93	1.68	1.80	1.06	0.02	0.23	0.65	1.07	1.57	2.00	2.53	2.76	1.44
1871	2.83	3.14	2.84	2.31	1.92	2.02	2.15	2.50	2.90	3.44	3.80	4.18	2.84
1872	4.34	4.57	4.76	4.31	4.01	3.65	3.64	3.83	4.05	4.23	4.38	4.66	4.20
1873	4.68	4.75	4.64	3.25	2.13	2.02	2.15	2.20	2.67	3.09	3.30	3.16	3.17
1874	2.68	2.21	1.91	1.80	1.68	1.57	1.65	1.91	2.51	3.07	3.55	3.87	2.37

CLEVELAND.

Mean monthly water-level, in feet and decimals, below plane of reference for Lake Erie.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.
1859	......	......	......	......	......	......	0.76	0.87	1.28	1.64	1.98	1.68	......
1860	1.85	2.21	1.81	1.11	0.90	0.93	1.19	1.35	1.69	1.99	2.08	2.24	1.61
1861	2.50	2.78	2.34	1.30	0.87	0.80	1.05	1.01	1.19	1.42	1.44	1.67	1.53
1862	1.68	1.97	1.83	0.93	0.69	0.69	0.72	1.10	1.41	1.79	2.13	2.10	1.42
1863	1.65	1.36	1.42	1.30	1.12	1.26	1.38	1.46	1.85	2.29	2.70	2.73	1.71
1864	3.02	2.87	2.66	2.16	1.46	1.51	1.77	2.04	2.26	2.57	2.74	2.67	2.31
1865	3.10	3.68	3.36	2.64	2.06	2.08	2.12	2.20	2.24	2.54	2.92	3.06	2.67
1866	3.33	3.49	3.10	2.52	2.30	2.04	1.93	2.18	2.24	2.25	2.49	2.48	2.53
1867	2.77	3.09	2.69	2.37	1.85	1.54	1.73	2.04	2.43	2.77	3.27	3.49	2.50
1868	3.69	4.07	3.48	2.65	2.20	1.81	1.84	2.36	2.63	3.08	3.24	3.45	2.88
1869	3.46	3.53	3.05	2.75	2.20	1.81	1.53	1.63	1.90	2.35	2.81	2.46	2.46
1870	2.22	1.99	2.22	1.57	1.36	1.39	1.35	1.40	1.65	2.03	2.33	2.45	1.83
1871	2.66	2.99	2.54	2.06	1.79	1.76	1.78	1.99	2.16	2.83	3.01	3.45	2.42
1872	3.53	3.77	3.86	3.66	3.22	2.85	2.86	2.89	3.12	3.29	3.62	3.85	3.38
1873	3.95	3.94	3.87	2.59	1.92	1.84	1.86	1.92	2.32	2.62	2.82	2.45	2.67
1874	2.06	2.01	1.98	1.81	1.72	1.65	1.62	1.78	2.24	2.68	3.10	3.31	2.16
1875	3.54	3.71	3.57	3.17	2.70	2.27	2.14	2.15	2.29	2.78	2.93	2.71	2.83
1876	2.75	2.19	1.54	1.02	0.70	......	......	......	......	......	......	......	......

ERIE.

Mean monthly water-level, in feet and decimals, below plane of reference for Lake Erie.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.
1859	......	......	......	......	......	0.53	0.83	1.27	1.92	2.11	2.34	2.16	......
1860	......	......	......	......	......	......	......	1.20	1.49	1.93	1.84	2.07	......
1861	......	......	......	1.35	0.83	0.78	0.96	1.08	1.19	1.30	1.45	1.65	......
1862	......	......	......	1.16	0.76	0.83	0.78	1.16	1.55	1.76	2.03	2.01	......
1863	......	......	......	......	......	1.25	1.76	1.93	2.53	2.91	2.97	3.05	......
1864	......	......	......	2.10	1.40	1.37	1.78	2.17	2.54	2.60	2.40	2.31	......
1865	......	......	......	2.49	2.07	1.98	2.04	2.04	2.07	2.38	2.53	2.77	......
1866	......	......	......	2.37	2.18	1.97	1.80	1.92	1.97	2.00	2.31	2.16	......
1867	......	......	......	2.13	1.85	1.78	2.14	2.35	2.33	2.67	2.85	2.87	......
1868	......	......	......	2.46	2.31	1.84	1.69	2.13	2.39	2.84	3.14	2.84	......
1869	......	......	......	3.11	2.42	1.91	1.43	1.53	1.74	1.96	2.44	2.13	......
1870	1.51	1.56	1.63	1.66	1.56	1.53	1.39	1.38	1.75	1.88	2.20	2.33	1.70
1871	2.25	2.26	2.21	1.98	1.73	1.66	1.63	1.98	2.10	2.58	2.84	2.88	2.17
1872	3.02	......	3.61	3.59	3.16	2.77	2.68	2.73	2.90	3.27	3.31	3.60	......
1873	3.72	3.94	3.61	2.55	1.89	1.88	1.65	1.97	2.22	2.47	2.53	2.16	2.55
1874	1.90	1.95	1.67	1.99	1.78	1.59	1.63	1.86	2.15	2.32	3.22	2.85	2.08
1875	3.02	......	3.34	2.97	2.37	2.21	2.11	2.14	2.18	2.43	2.74	2.59	......
1876	2.34	1.82	1.42	0.83	0.55	......	......	......	......	......	......	......	......

MONROE.

Mean monthly water-level, in feet and decimals, below plane of reference for Lake Erie.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.
1859	......	......	......	......	......	......	0.61	0.82	1.39	1.85	2.02	1.59	......
1860	1.83	2.17	2.07	1.31	0.95	1.11	1.18	1.20	1.62	1.83	2.10	2.24	1.63
1861	2.42	2.69	2.25	1.17	0.79	0.69	0.98	0.84	1.16	1.42	1.60	1.58	1.47
1862	1.63	1.95	1.51	......	......	......	......	......	......	......	......	......	......

PORT COLBORNE.

Mean monthly water-level, in feet and decimals, below plane of reference for Lake Erie.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.
1854	......	......	......	......	......	......	......	1. 94	2. 27	2. 41	2. 11	2. 69	......
1855	2. 72	3. 03	2. 97	2. 68	2. 16	1. 88	1. 38	1. 16	1. 81	1. 57	1. 50	1. 22	2. 01
1856	1. 86	2. 26	2. 59	2. 10	2. 14	1. 76	1. 73	1. 88	2. 13	2. 79	2. 91	2. 62	2. 23
1857	3. 37	3. 34	1. 75	1. 20	1. 61	1. 23	1. 14	1. 18	1. 43	1. 89	1. 35	1. 35	1. 74
1858	1. 26	1. 66	1. 63	1. 52	1. 26	—. 10	—. 05	. 04	. 60	. 70	1. 12	1. 02	0. 89
1859	1. 03	1. 25	. 84	. 27	. 39	. 42	. 36	. 66	1. 26	1. 05	1. 23	1. 43	0. 85
1860	1. 54	1. 88	1. 37	1. 19	. 98	. 47	. 84	1. 02	1. 31	1. 65	1. 31	1. 71	1. 27
1861	2. 15	2. 52	1. 95	1. 28	. 62	1. 09	. 69	. 87	. 93	. 82	. 87	1. 02	1. 23
1862	1. 29	1. 52	1. 73	1. 10	. 46	. 52	. 38	. 71	1. 00	1. 19	1. 65	1. 50	1. 09
1863	1. 08	1. 19	. 98	1. 17	1. 07	1. 13	1. 25	1. 07	1. 45	1. 54	1. 92	1. 63	1. 29
1864	1. 89	2. 29	2. 35	1. 82	1. 14	1. 13	1. 41	1. 53	1. 70	1. 84	1. 74	1. 88	1. 73
1865	2. 56	3. 37	3. 11	2. 29	2. 07	1. 85	1. 97	2. 23	2. 12	2. 14	2. 35	2. 52	2. 38
1866	2. 44	3. 31	2. 95	2. 28	1. 96	1. 73	1. 57	1. 72	2. 19	1. 51	1. 86	1. 41	2. 08
1867	2. 27	3. 65	2. 56	2. 19	1. 64	1. 37	1. 52	1. 80	2. 30	2. 53	2. 84	3. 15	2. 32
1868	3. 19	3. 88	3. 49	2. 32	2. 23	1. 64	1. 70	2. 07	2. 30	2. 95	2. 89	2. 71	2. 61
1869	3. 24	3. 17	3. 36	2. 64	2. 32	1. 73	1. 34	1. 59	1. 87	1. 95	2. 26	2. 12	2. 30
1870	1. 60	1. 90	2. 31	1. 60	1. 39	1. 31	1. 12	1. 31	1. 84	1. 75	1. 96	1. 89	1. 67
1871	2. 47	2. 87	2. 32	1. 76	1. 78	1. 51	1. 57	1. 82	2. 11	2. 51	2. 91	2. 60	2. 19
1872	3. 32	3. 79	3. 85	3. 57	3. 03	2. 73	2. 62	2. 83	2. 77	3. 29	2. 83	3. 36	3. 17
1873	3. 39	3. 71	3. 76	2. 61	1. 99	1. 92	1. 75	2. 08	2. 20	2. 47	2. 38	2. 20	2. 54
1874	1. 77	1. 98	1. 64	1. 91	1. 66	1. 60	1. 74	2. 00	2. 30	2. 52	2. 45	2. 77	2. 03
1875	3. 05	3. 46	3. 53	2. 94	2. 33	2. 20	2. 13	2. 18	2. 28	......	......	......	......

DETROIT.

Mean monthly water level, in feet and decimals, below plane of reference for Detroit River at Detroit.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.
1867	......	......	......	......	1. 70	1. 35	1. 39	1. 60	1. 91	2. 29	2. 78	2. 98	......
1868	......	......	......	2. 59	2. 15	1. 85	1. 90	2. 22	2. 47	2. 86	3. 08	3. 12	......
1869	......	......	......	2. 91	2. 93	2. 22	1. 77	1. 74	1. 95	2. 41	2. 78	.....	......
1870	......	......	......	2. 03	1. 63	1. 55	1. 29	1. 35	1. 57	1. 91	2. 22	2. 30	......
1871	......	......	1. 73	1. 81	1. 57	1. 54	1. 46	1. 64	1. 92	2. 49	2. 68	......	......
1872	......	......	......	2. 98	2. 75	2. 34	2. 28	2. 35	2. 55	2. 71	3. 14	3. 35	......
1873	3. 66	3. 46	3. 40	2. 23	1. 97	1. 85	1. 72	1. 75	2. 10	2. 33	2. 47	2. 19	2. 43
1874	2. 43	3. 14	2. 33	1. 88	1. 94	1. 78	1. 58	1. 68	2. 04	2. 38	2. 83	2. 87	2. 24
1875	2. 76	2. 89	2. 78	2. 81	2. 40	2. 20	2. 02	1. 97	2. 11	2. 47	2. 48	2. 53	2. 45
1876	2. 52	2. 20	1. 94	1. 30	0. 93	......	......	......	......	......	......	......	......

MILWAUKEE.

Mean monthly water-level, in feet and decimals, below plane of reference for Lakes Michigan and Huron.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.
1859	......	......	......	......	......	......	......	1.08	1.38	1.47	1.88	1.94	......
1860	2.18	2.00	1.97	1.84	1.72	1.60	1.56	1.75	1.95	2.26	2.59	2.75	2.01
1861	2.86	2.77	2.38	2.28	1.86	1.70	1.57	1.33	1.64	1.76	1.99	2.16	2.03
1862	2.36	2.51	2.21	2.05	1.80	1.67	1.77	1.78	1.85	1.96	2.35	2.49	2.07
1863	2.56	2.51	2.52	2.52	2.31	2.22	2.27	2.40	2.58	2.67	3.11	2.77	2.54
1864	3.00	3.14	2.89	3.18	2.67	2.68	2.78	2.96	3.23	3.62	3.79	3.92	3.16
1865	4.13	4.04	3.87	3.38	3.22	3.18	2.75	2.73	2.85	3.09	3.65	3.96	3.40
1866	4.22	4.46	4.41	3.96	3.78	3.49	3.23	3.17	3.32	3.43	3.52	3.78	3.73
1867	3.80	3.75	3.57	3.28	3.06	2.75	2.60	2.67	2.94	3.27	3.73	4.08	3.29
1868	4.24	4.28	3.60	3.70	3.42	3.21	3.18	3.52	3.76	3.99	4.06	4.34	3.78
1869	4.44	4.37	4.63	4.26	3.93	3.40	3.02	2.76	2.87	3.23	3.35	3.63	3.66
1870	3.57	3.48	3.18	2.76	2.42	2.28	2.17	2.26	2.12	2.52	2.92	3.27	2.75
1871	3.12	3.20	2.60	2.40	2.05	2.01	1.98	2.21	2.88	3.57	3.62	4.21	2.82
1872	4.34	4.34	4.56	4.31	4.06	3.69	3.66	3.68	3.75	3.87	4.16	4.82	4.10
1873	4.82	4.78	4.47	3.90	3.34	2.71	2.75	2.65	2.84	2.90	3.13	3.17	3.45
1874	3.21	2.92	2.77	2.87	2.89	2.52	2.59	2.58	2.83	3.18	3.38	3.72	2.96
1875	3.92	3.99	3.93	3.57	3.01	2.77	2.80	2.63	2.70	2.85	3.06	3.25	3.21
1876	3.30	3.10	2.77	2.57	1.95	......	......	......	......	......	......	......	......

CHICAGO.

Mean monthly water-level, in feet and decimals, below plane of reference for Lakes Michigan and Huron.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.
1865	4.39	4.13	3.79	3.69	3.19	3.09	2.79	2.79	2.79	2.99	3.69	4.29	3.47
1866	4.33	4.52	4.32	4.05	3.85	3.52	3.25	3.24	3.18	3.50	3.61	3.76	3.76
1867	3.82	3.53	3.56	3.31	2.98	2.73	2.64	2.69	2.95	3.27	3.71	4.10	3.27
1868	4.23	4.31	3.65	3.74	3.35	3.23	3.17	3.49	3.74	4.00	4.11	4.38	3.78
1869	4.60	4.26	......	......	......	......	......	......	......	......	......	......	......

POINT AUX BARQUES.

Mean monthly water-level, in feet and decimals, below plane of reference for Lakes Michigan and Huron.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.
1859	......	......	......	......	1.38	1.08	.90	.99	1.26	1.46	1.72	1.82	......
1860	2.02	2.07	1.93	1.96	1.91	1.67	1.58	1.66	1.85	2.23	2.35	2.65	1.99
1861	2.86	2.82	2.68	2.48	1.86	1.52	1.40	1.29	1.37	1.59	1.90	2.03	1.98
1862	2.41	2.42	2.51	2.30	1.93	1.81	1.76	1.78	2.00	1.72	2.04	2.33	2.08
1863	2.49	2.64	2.69	2.62	2.30	2.17	2.26	2.25	2.39	2.65	2.69	2.92	2.51
1864	3.06	3.10	3.10	2.90	2.47	2.46	2.51	2.62	2.94	......	......	......	......

PORT AUSTIN.

Mean monthly water-level, in feet and decimals, below plane of reference for Lakes Michigan and Huron.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.
1871	......	......	......	......	......	......	......	2. 29	2. 61	3. 11	3. 32	3. 69	......
1872	3. 86	4. 06	......	4. 14	3. 74	3. 34	3. 24	3. 27	3. 37	3. 49	3. 79	4. 08	......
1873	4. 25	4. 28	4. 21	3. 80	3. 30	2. 90	2. 70	2. 69	2. 86	2. 89	2. 99	3. 15	3. 34
1874	3. 13	2. 99	2. 85	3. 00	2. 95	2. 61	2. 45	2. 56	2. 72	2. 96	3. 23	3. 48	2. 91
1875	3. 59	3. 96	......	3. 53	3. 15	2. 79	2. 72	2. 77	2. 74	3. 03	3. 13	3. 31	......
1876	3. 20	3. 24	3. 12	2. 82	2. 28	......	......	......	......	......	......	......	......

SAULT STE. MARIE.

Mean monthly water-level, in feet and decimals, below plane of reference for Lake Superior.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.
1870	......	......	......	......	......	......	......	......	......	......	2. 94	3. 16	......
1871	3. 60	3. 75	4. 02	3. 89	3. 31	2. 90	2. 73	2. 81	2. 75	2. 95	3. 18	3. 57	3. 29
1872	3. 81	3. 90	4. 13	4. 18	3. 29	3. 11	2. 72	2. 39	2. 33	2. 48	2. 62	3. 08	3. 17
1873	3. 47	3. 65	3. 62	3. 61	3. 05	2. 85	2. 35	2. 15	2. 09	2. 25	2. 33	2. 64	2. 84
1874	3. 29	3. 45	3. 56	3. 68	3. 15	2. 83	2. 45	2. 40	2. 41	2. 28	2. 41	2. 61	2. 88
1875	3. 06	3. 31	3. 36	3. 11	2. 80	2. 52	2. 41	2. 40	2. 12	2. 25	2. 53	3. 09	2. 75
1876	3. 12	3. 17	3. 37	3. 39	2. 66	......	......	......	......	......	......	......	......

MARQUETTE.

Mean monthly water-level, in feet and decimals, below plane of reference for Lake Superior.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.
1871	......	......	......	......	......	......	......	......	......	2. 92	......	3. 55	......
1872	3. 85	3. 96	4. 08	4. 18	3. 53	3. 15	2. 88	2. 71	2. 55	2. 65	2. 80	3. 10	3. 29
1873	3. 20	......	......	......	3. 01	2. 71	2. 42	2. 24	2. 18	2. 28	2. 42	2. 72	......
1874	......	3. 19	3. 23	3. 13	3. 06	2. 86	2. 48	2. 39	2. 29	2. 23	2. 41	2. 72	......
1875	3. 04	3. 08	3. 04	3. 04	2. 82	2. 46	2. 47	2. 38	2. 15	2. 30	2. 44	2. 64	2. 65
1876	2. 84	3. 05	3. 14	3. 11	2. 57	......	......	......	......	......	......	......	......

SUPERIOR.

Mean monthly water-level, in feet and decimals, below plane of reference for Lake Superior.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.
1859	......	......	......	......	......	......	1. 25	1. 16	1. 23	1. 51	1. 56	......	......
1860	......	......	......	2. 52	2. 29	2. 12	2. 16	2. 11	2. 13	2. 09	2. 26	......	......
1861	......	3. 06	3. 20	2. 79	2. 16	2. 01	1. 85	1. 89	1. 98	1. 95	2. 29	2. 67	......
1862	3. 02	3. 21	3. 18	3. 12	2. 44	2. 45	2. 48	2. 31	2. 19	2. 26	2. 59	2. 86	2. 68
1863	3. 05	3. 18	3. 35	3. 31	3. 18	3. 26	3. 12	2. 50	2. 48	2. 65	3. 00	3. 11	3. 02
1864	3. 40	3. 61	3. 54	3. 52	3. 36	3. 21	3. 12	3. 11	2. 96	3. 22	3. 41	3. 56	3. 34
1865	3. 74	3. 75	3. 88	3. 44	2. 95	2. 54	2. 22	2. 14	2. 13	2. 34	2. 87	3. 18	2. 93
1866	3. 47	3. 68	3. 68	3. 23	2. 98	2. 79	2. 50	2. 27	2. 54	2. 52	2. 85	2. 74	2. 94
1867	3. 01	3. 12	3. 31	3. 09	3. 09	2. 49	2. 16	2. 28	2. 20	2. 22	2. 65	2. 97	2. 72
1868	3. 13	3. 72	3. 36	3. 17	2. 77	2. 86	2. 64	2. 72	2. 59	2. 62	2. 46	2. 89	2. 91
1869	3. 11	3. 35	3. 80	3. 22	2. 82	2. 81	2. 44	1. 98	1. 13	1. 65	1. 99	2. 64	2. 58
1870	2. 89	3. 10	3. 09	2. 99	2. 66	2. 85	2. 66	2. 66	2. 49	2. 65	2. 83	3. 76	2. 89
1871	3. 85	4. 45	4. 03	3. 53	3. 00	2. 88	2. 81	2. 75	2. 65	2. 72	2. 79	3. 53	3. 25

DULUTH.

Mean monthly water-level, in feet and decimals, below plane of reference for Lake Superior.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly mean.
1872	......	......	......	......	......	2.99	2.75	2.47	2.36	2.51	2.73	3.06	......
1873	3.24	3.36	3.33	3.14	2.90	2.51	2.24	1.95	2.07	......	......	......	......

APPENDIX I.—ASTRONOMICAL WORK.

REPORT OF MR. A. R. FLINT, ASSISTANT ENGINEER.

OFFICE UNITED STATES LAKE SURVEY,
Detroit, Mich., June 15, 1876.

GENERAL: I have the honor to submit the following report upon the instruments used, the methods of observing, recording, and reducing, employed in determining the difference of longitude between the Lake-Survey observatory at Detroit and trigonometrical stations Tonawanda and Mannsville, N. Y.

The programme embraced the following objects to be obtained:

1. Observations to determine the relative personal equation between the Detroit observer, First Lieut. D. W. Lockwood, Corps of Engineers, and myself, on two nights.
2. Observations on four nights to determine the difference of time between Detroit and Tonawanda, N. Y.
3. Observations for determining the latitude of Tonawanda station.
4. Observations on four nights to determine the difference of time between Detroit and Mannsville, N. Y.
5. Observations on two nights to determine the relative personal equation between observers after returning from the field-work.

The observations were commenced on August 30, and completed on December 27, 1875.

The instruments used by myself were astronomical transit No. 2, by Troughton and Simms, of 29-inches focal length and reticule of 19 threads; sidereal break-circuit chronometer, by Negus, No. 1524; chronograph, by Bond & Son, No. 245; zenith-telescope No. 19, by Würdemann, for latitude.

The star-signals, and observations, and comparisons of clock and chronometer, both in Detroit and in the field, were recorded on the chronograph.

The chronometer was placed in a local circuit, in which were chronograph relay Morse relay, and signal-key, the battery being composed of two Daniels' cells.

By a system of switches, the current of the local or main line could be sent through the coils or points of the Morse relay at pleasure.

The switches were so arranged that when the current of local circuit was through the coils that of the main circuit was complete over the points. By this arrangement the Morse relay acted as a repeater, the current from main line not passing through the chronometer during comparisons.

Before commencing the observations for personal equation, the instruments, except chronometer, were cleaned and adjusted. The chronograph and chronometer were placed in a separate room. The transit was mounted on the west pier of the observatory.

The method of determining the relative personal equation between observers was the same precisely as was employed in determining the difference of time between Detroit and the field-stations, the transits being mounted 5 feet apart, and each observer working independently of the other.

The following programme was followed both in the observatory and in the field:

Polar star. Reversal. Polar star.
Equatorial stars.
Reversal.
Equatorial stars.
Polar star. Reversal. Polar star.
Clock and chronometer comparisons in duplicate.
Polar star. Reversal. Polar star.
Equatorial stars.
Reversal.
Equatorial stars.
Polar star. Reversal. Polar star.

The above programme was followed as closely as the weather would permit, each observing the same stars when possible.

Observations were made at Detroit for determining the thread-intervals of the transit before leaving for the field. This determination was used for reducing the work for personal equation on August 30 and 31.

Before commencing work in the field, the focal length of the telescope was slightly changed and an entirely new determination of thread-intervals was made. This latter determination was used for the reduction of the field-work and personal equation of December 22 and 27.

The observations for thread-intervals were made on standard circumpolar stars, and were entirely independent of the longitude work.

These observations extended over a period of about ten weeks, being made on nights when signals were not exchanged with Detroit.

The value of one division of the striding-level was carefully determined before commencing work.

After arriving at Tonawanda, it was found that the tube was loose in its mountings, so as to frequently change its adjustments in reversing.

Two thin pine wedges were gently pressed over each end of the glass tube, sufficient to hold it in place. These wedges remained in place through all the season's work subsequent to September 17, and another careful determination of the value of one division was made. It was found that the value had changed very considerably. It was assumed that the value had remained constant while the wedges were in, and the value last determined was used for the field-work, and personal equation after returning to Detroit. After the wedges were removed, the value of the level was found to be the same as at first determined.

The pivot-correction was determined, and the values found are in terms of the level-divisions with the wedges in.

The values of the transit and level constants will be found in office report 611.

The reductions of the observations for time and personal equation have been made by the method of least squares, treating uniformly as unknown quantities the azimuth, collimation, rate, and correction to an assumed chronometer error.

Each conditional equation is of the form

$$\tau_0 + Aa + Cc + R\zeta = \tau \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (1)$$

Where

$$\tau_0 = T + \text{Di. Aber} + Bb + C\triangle i - d \quad . \; . \; . \; . \; . \; . \; . \quad (2)$$

Let $\tau =$ chronometer error;
$T =$ observed time;
Di. Ab. $=$ diurnal aberration;
$B =$ level factor;
$A =$ azimuth factor;
$C =$ collimation factor;
$R =$ rate factor, expressed in parts of a sidereal hour;
a, c, and $\zeta =$ respectively, deviation, collimation, and rate;
$b =$ value of inclination, expressed in seconds of time;
$C\triangle i =$ reduction of mean of threads observed to middle thread;
$\alpha =$ right ascension of star.

Assume $\tau_0 - \tau = \triangle T + d$, substituting in (1)

$$\triangle T + Aa + Cc + R\zeta + d = 0, \quad . \; . \; . \; . \; . \; . \; . \; . \quad (3)$$

in which $\triangle T$ is a correction to an assumed τ, and d a known term.

τ is assumed constant for each conditional equation on the same night.

All the terms of the second member of (2) are known, and are applied before forming the normal equations.

The equatorial stars are usually observed over fifteen threads, but only seven have been used in the reductions.

On the polar stars, from five to nine threads were observed on each side of reversal, according to circumstances.

The mean error of observation over seven threads was determined from a number of stars within a few minutes of the equator, giving each observation equal weight.

The mean errors were also determined for seven threads of each polar star used in the time-determinations.

All the observations made during the field-work were included.

The weight of a star south of the zenith was assumed to be unity.

Then, since the weights are inversely proportional to the squares of the mean errors, we have the weight of a polar star

$$p\zeta = \frac{\varepsilon_e^2}{\varepsilon_\zeta^2}$$

When more than seven or less than seven threads were used, the weight was computed by formula given by Chauvenet, (Practical Astronomy, vol. II, page 198, "(129)".

The observatory at Tonawanda was located about 10 yards east of the trigonometri-

cal station, and at Mannsville about 700 yards west-southwest of station. The azimuth and distance in each case was carefully determined.

At Mannsville, the observatory was connected with the steeple of the Methodist church, a point located by the primary triangulation. The church was about 30 yards west of observatory.

All the reductions have been computed in duplicate and checked.

The time-computations for Tonawanda and Mannsville, and for one night of personal equation, have been made by Assistant Engineer G. Y. Wisner and myself.

Messrs. J. H. Darling and L. L. Wheeler reduced the observations for personal equation for three nights, and also read the chronograph-sheets in duplicate.

Tables A, B, and C, appended to report 633, give the individual results for each night's work, uncorrected for wave and armature time.

Very unfavorable weather was experiened at Detroit and each field-station.

Five nights have been reduced for Tonawanda and five for Mannsville.

At the latter point, six nights were obtained, but the last one, November 29, has not been reduced. I have little confidence in my own work for that night.

The weather was very cold, and great difficulty was experienced in making the chronograph run.

The bubble of the level is non-adjustable, and it was necessary to keep it in a warm place in order to read it at all.

The reductions will be found in office reports Nos. 630, 631, 632, and 633.

Respectfully submitted.

A. R. FLINT,
Assistant Engineer.

Gen. C. B. COMSTOCK,
Major of Engineers.

APPENDIX K.—GEOGRAPHICAL POSITIONS, SAINT LAWRENCE RIVER.—SECONDARY TRIANGULATION.

There are 140 triangles, extending over a distance of 106 miles from boundary post No. 2, near Saint Regis, to Bear Point, near Cape Vincent. The sides of the triangles are derived from bases, as follows:

Triangles from 1 to 49, a distance of 24 miles, from Morrisburg base.
Triangles from 50 to 76, a distance of 20 miles, from mean of Morrisburg and Ogdensburg bases.
Triangles from 77 to 95, a distance of 10 miles, from mean of Ogdensburg and Maitland bases.
Triangles from 96 to 122, a distance of 33 miles, from mean of Maitland and Clayton bases.
Triangles from 123 to 140, a distance of 19 miles, from mean of Clayton and Cape Vincent bases, giving the latter double weight.

Comparison of bases.

	Meters.
Morrisburgh as measured	2612.738
Morrisburgh as computed from Ogdensburgh	2612.670
Approximate difference	1 in 40,000
Ogdensburgh as measured	1193.978
Ogdensburgh as computed from Maitland	1193.995
Approximate difference	1 in 70,000
Maitland as measured	780.999
Maitland as computed from Clayton	781.010
Approximate difference	1 in 70,000
Clayton as measured	1057.230
Clayton as computed from Cape Vincent	1057.275
Approximate difference	1 in 25,000
Cape Vincent as measured	1830.996
Cape Vincent as computed from Sandy Creek, primary base	1830.934
Approximate difference	1 in 30,000

The only adjustment of triangles was to make the sum of the three angles equal 180°.

Measurement of angles.—The angles as read closed the triangles within the limit of 6″, with the exception of eight triangles near the east end of the work, the greatest error being in triangle No. 4, an error of 12″.6. These triangles with largest errors were well proportioned, having no angle less than 32°.

Azimuth.—The azimuth used in the geodetic computation was that of triangulation-station Windmill from triangulation station Light-house, Ogdensburgh, as 206° 54′ 47″.00. This value is the mean of three transferred values, observed at Stations Jinks, Johnstown, and Soper's Hill, which had a range of 8″.7. The azimuth of the line triangulation-station Carleton to triangulation-station Sir John, computed from the above value, differs from that computed from the Sandy Creek base azimuth by 6″.5.

Latitude and longitude.—The latitude and longitude, upon which the geodetic computation depends, are those of Light-House Peak, Ogdensburgh, as determined in 1868, whose latitude is 44° 41′ 53″.52, and longitude is 75° 30′ 19″.32 west from Greenwich.

The geodetic computation, carried to thousandths of a second in latitude and longitude, checks completely the computation of triangulation.

Geographical positions.

SAINT LAWRENCE RIVER SECONDARY TRIANGULATION.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back-azimuth.	Distance.	Distance.	Remarks.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Miles.*	
Triangulation station boundary-post No. 2.	44 59 59.51	74 39 37.99	93 06 24	Triangulation-station 12	273 05 23	1895.0	1.18	
Triangulation-station 13	44 59 23.74	74 40 35.06	228 32 14	Triangulation-station boundary-post No. 2.	48 32 55	1667.9	1.04	
			151 58 23	Triangulation-station 12	331 58 03	1367.0	0.85	
Triangulation-station 11	44 59 39.18	74 41 46.15	231 24 05	Triangulation-station 12	51 24 34	1170.1	0.73	
			287 01 03	Triangulation-station 13	107 01 53	1628.4	1.01	
			80 45 52	Triangulation-station 8	260 45 08	1396.3	0.87	
Triangulation-station 10	45 00 15.94	74 42 14.33	331 27 04	Triangulation-station 11	151 27 24	1291.5	0.80	
			79 10 25	Triangulation-station 21, (A. C. L., 1871.)	259 09 57	879.2	0.55	
Triangulation-station 12	45 00 02.83	74 41 04.40	104 48 12	Triangulation-station 10	284 49 23	1584.1	0.98	
Court-house square, Cornwall, Ont	45 00 57	74 43 44						Southeast corner of court-house square on Canal street graphically from triangulation-station 10.
Triangulation-station 21, (A. C. L., 1871.)	45 00 10.58	74 42 53.77	50 04 02	Triangulation-station 7	230 03 15	1897.8	1.18	
Triangulation-station 8	44 59 31.92	74 42 49.08	175 05 06	Triangulation-station 21, (A. C. L., 1871.)	355 05 03	1197.9	0.74	
			209 14 49	Triangulation-station 10	29 15 14	1557.3	0.97	
Triangulation-station 6	44 59 08.42	74 43 44.26	239 01 46	Triangulation-station 8	59 02 25	1409.4	0.88	
			153 28 59	Triangulation-station 7	333 28 48	782.7	0.49	
Triangulation-station 7	44 59 31.11	74 44 00.21	89 16 22	Triangulation-station 5	269 15 52	922.8	0.57	
			269 04 48	Triangulation-station 8	89 05 39	1558.1	0.97	
Triangulation-station 5	44 59 30.73	74 44 42.34	111 37 20	Triangulation-station 3	291 36 41	1297.0	0.81	
Triangulation-station 4	44 59 07.58	74 44 29.82	159 00 56	Triangulation-station 5	339 00 47	765.5	0.48	
			221 45 26	Triangulation-station 7	41 45 47	974.0	0.61	
			268 29 33	Triangulation-station 6	88 30 06	998.5	0.62	
Triangulation-station 2	44 59 03.95	74 45 28.32	171 20 12	Triangulation-station 3	351 20 05	1319.4	0.82	
			265 00 25	Triangulation-station 4	85 01 06	1286.2	0.80	
Triangulation-station 3	44 59 46.21	74 45 37.40	155 58 47	Triangulation-station Gut	335 58 27	1505.0	0.94	
Triangulation-station 1	44 59 25.30	74 46 07.20	225 18 40	Triangulation-station 3	45 19 01	918.1	0.57	
			307 43 14	Triangulation-station 2	127 43 41	1076.6	0.67	
Triangulation-station Gut	45 00 30.75	74 46 05.38	95 26 31	Triangulation-station 16	275 25 56	1112.0	0.69	
Triangulation-station 16	45 00 34.16	74 46 55.93	116 04 35	Triangulation-station 18	296 04 00	1209.9	0.75	
Triangulation-station Massena Point.	45 00 01.67	74 46 11.79	136 03 51	Triangulation-station 15	316 03 20	1392.9	0.87	
			354 52 40	Triangulation-station 1	174 52 43	1127.1	0.70	
Triangulation-station 18	45 00 51.39	74 47 45.57	112 41 36	Triangulation-station Maple Grove	292 40 46	1682.5	1.05	

Triangulation-station 17	44 59 52.58	74 47 27.38	167 37 47	Triangulation-station 18	347 37 34	1858.5	1.15	
			260 22 19	Triangulation-station Massena Point	80 23 12	1679.0	1.04	
Triangulation-station 19	45 00 30.18	74 48 41.32	165 43 06	Triangulation-station Maple Grove	345 42 55	1345.3	0.84	
			305 37 39	Triangulation-station 17	125 38 31	1992.0	1 24	
Triangulation-station 23	45 00 37.57	74 49 34.32	281 07 25	Triangulation-station 19	101 08 02	1182.8	0.73	
Triangulation-station East Base Maple Grove.	45 01 37.12	74 49 02.46	100 08 27	Triangulation-station West Base Maple Grove.	280 08 03	760.9	0.47	
Triangulation-station Maple Grove	45 01 12.41	74 48 56.47	170 14 57	Triangulation-station East Base Maple Grove.	350 14 53	773.8	0.48	
			91 39 49	Triangulation-station 25	271 38 56	1642.5	1.02	
Triangulation-station West Base Maple Grove.	45 01 41.46	74 49 36.68	99 10 54	Triangulation-station 20	279 10 16	1177.4	0.73	
Lock-gate, Maple Grove, Out	45 01 06	74 48 27	....	....	....	....	....	South side of upper lock-gate graphically from triangulation-station 18.
Triangulation-station 25	45 01 13.95	74 50 11.47	221 53 12	Triangulation-station West Base Maple Grove.	41 53 36	1140.6	0.71	
			324 04 36	Triangulation-station 23	144 05 02	1386.5	0.86	
Triangulation-station 20	45 01 47.54	74 50 29.78	26 55 57	Triangulation-station 27	206 55 34	1560.5	0.97	
			338 51 40	Triangulation-station 25	158 51 53	1111.7	0.69	
Triangulation-station Moulinette	45 01 35.37	74 51 32.75	254 45 01	Triangulation-station 20	74 45 45	1428.6	0.89	
			326 31 08	Triangulation-station 27	146 31 29	1217.7	0.76	
Triangulation-station 27	45 01 02.47	74 51 02.05	....	....	....	....	....	
Triangulation-station 24	45 00 13.03	74 53 27.38	244 21 49	Triangulation-station 27	64 23 31	3529.1	2.19	
			56 33 28	Triangulation-station 26	236 33 03	912.9	0.57	
Triangulation-station 22	45 00 49.10	74 52 58.35	29 42 55	Triangulation-station 24	209 42 34	1282.1	0.80	
			232 41 11	Triangulation-station Moulinette	52 42 11	2356.5	1.46	
Triangulation-station 29	45 00 18.46	74 53 01.94	184 44 23	Triangulation-station 22	4 44 26	949.2	0.59	
Triangulation-station 31	44 59 57.36	74 53 24.23	216 51 16	Triangulation-station 29	36 51 32	814.0	0.51	
			171 53 55	Triangulation-station 24	351 53 53	488.6	0.30	
Triangulation-station 28	44 59 48.65	74 54 25.66	36 05 59	Triangulation-station 35	216 05 00	3112.9	1.93	
Triangulation-station 26	44 59 56.72	74 54 02.16	64 09 20	Triangulation-station 28	244 09 03	571.8	0.36	
Triangulation-station 30	44 59 33.72	74 56 02.02	61 04 56	Triangulation-station Croyle's Island	241 02 59	4125.7	2.56	
Triangulation-station 33	44 59 32.41	74 54 06.62	90 55 42	Triangulation-station 30	270 54 21	2527.9	1.57	
			187 24 45	Triangulation-station 26	7 24 48	756.8	0.47	
			236 19 30	Triangulation-station 31	50 20 00	1206.1	0.75	
Triangulation-station Ault	44 57 43.51	75 01 15.39	20 10 46	Triangulation-station Whalen	200 10 12	3017.6	1.88	
Triangulation-station Croyl's Island	44 58 29.06	74 58 46.85	66 39 08	Triangulation station Ault	246 37 23	3545.3	2.20	
Triangulation-station 35	44 58 27.15	74 55 49.37	90 52 58	Triangulation-station Croyle's Island	270 50 52	3888.8	2.42	
			228 09 55	Triangulation station 33	48 11 07	3020.6	1.88	
Triangulation-station McLeod	44 57 05.72	74 59 41.19	243 39 05	Triangulation-station 35	63 41 49	5667.7	3.52	
Triangulation-station Wells	44 56 47.88	75 03 25.71	36 06 55	Triangulation-station Bradford	216 05 49	3466.1	2.15	
Triangulation-station Whalen	44 56 11.74	75 02 02.87	121 34 13	Triangulation-station Wells	301 33 14	2131.2	1.32	
			241 46 25	Triangulation-station McLeod	61 48 06	3524.4	2.19	
Triangulation-station Wilson	44 55 51.50	75 03 13.37	247 59 18	Triangulation-station Whalen	68 00 08	1667.1	1.04	
Triangulation-station Casselman	44 55 58.74	75 05 08.14	32 07 56	Triangulation-station Lawrence	212 07 07	2838.6	1.76	
Triangulation-station Bradford	44 55 17.16	75 04 58.87	170 59 58	Triangulation-station Casselman	350 59 52	1299.6	0.81	
			245 22 01	Triangulation-station Wilson	65 23 15	2544.7	1.58	
Triangulation-station Lawrence	44 54 40.86	75 06 16.98	109 50 24	Triangulation-station East Base Morrisburgh.	289 48 56	2893.4	1.80	
			236 48 25	Triangulation-station Bradford	56 49 20	2046.9	1.27	

Geographical positions—Continued.

SAINT LAWRENCE RIVER SECONDARY TRIANGULATION—Continued.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back-azimuth.	Distance.	Distance.	Remarks.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	Meters.	Miles.	
Lock-gate, Morrisburgh, Ontario	44 53 38	75 10 41	......	......	......	......	......	North side of upper lock-gate graphically from triangulation-station Alison.
Triangulation-station East Base Morrisburgh.	44 55 12.65	75 08 21.09	14 26 54	Triangulation-station Alison	194 26 27	3266.5	2.03	
			289 48 56	Triangulation-station Lawrence	109 50 24	2893.4	1.80	
Triangulation-station West Base Morrisburgh.	44 54 31.55	75 10 05.23	240 56 32	Triangulation-station East Base Morrisburgh.	60 57 45	2612.7	1.62	
			322 11 26	Triangulation-station Alison	142 12 13	2397.9	1.49	
Triangulation-station Alison	44 53 30.17	75 08 58.23	92 15 07	Triangulation-station Smith	272 12 43	4464.7	2.77	
			238 19 08	Triangulation-station Lawrence	58 21 02	4156.1	2.58	
Triangulation-station Waddington	44 52 34.18	75 10 44.81	233 31 32	Triangulation-station Alison	53 32 48	2908.0	1.81	
Public square, Waddington, N.Y	44 51 48	75 12 16	......	......	......	......	......	Intersection of streets passing through square graphically from triangulation-station Ogden.
Triangulation-station Smith	44 53 35.81	75 12 21.57	60 21 21	Triangulation-station Robertson	240 19 37	3719.7	2.31	
Triangulation-station Ogden	44 51 43.10	75 12 39.62	186 29 42	Triangulation-station Smith	6 29 55	3501.1	2.18	
			237 57 30	Triangulation-station Waddington	57 58 52	2972.5	1.85	
Triangulation-station Robertson	44 52 36.17	75 14 48.88	51 38 01	Triangulation-station Pine Tree	231 36 33	3484.7	2.17	
			299 59 19	Triangulation-station Ogden	120 00 51	3276.0	2.04	
Triangulation-station Ames	44 51 11.66	75 14 30.69	171 17 52	Triangulation-station Robertson	351 17 39	2638.9	1.64	
Lock-gate, Matilda, Ont	44 50 25	75 18 45	......	......	......	......	......	North side of upper lock-gate graphically from triangulation-station Pine Tree.
Triangulation-station Iroquois or Matilda.	44 50 22.55	75 18 51.20	328 06 57	Triangulation-station Sharp	148 07 43	2701.1	1.68	
Triangulation-station Pine Tree	44 51 26.08	75 16 53.33	52 51 36	Triangulation-station Iroquois or Matilda.	232 50 13	3246.8	2.02	
Triangulation-station Jinks	44 50 13.42	75 16 00.05	152 27 14	Triangulation-station Pine Tree	332 26 36	2529.4	1.57	
			227 29 59	Triangulation-station Ames	47 31 02	2661.2	1.65	
Triangulation-station Wort	44 48 53.62	75 20 58.81	46 12 20	Triangulation-station Stethem	226 11 31	2105.0	1.31	
Triangulation-station Binion	44 49 16.85	75 19 57.38	26 39 52	Triangulation-station Sparrowhawk	206 39 16	2514.8	1.56	
			62 01 28	Triangulation-station Wort	242 00 45	1528.1	0.95	
Triangulation-station Sharp	44 49 08.24	75 17 46.24	95 16 58	Triangulation-station Binion	275 15 25	2893.0	1.80	
			229 12 35	Triangulation-station Jinks	49 13 50	3080.5	1.91	
Triangulation-station Stethem	44 48 06.41	75 22 07.95	39 37 10	Triangulation-station Edwardsburg	219 36 41	1453 4	0.90	
Triangulation-station Sparrowhawk	44 48 04.03	75 20 48.74	92 25 31	Triangulation-station Stetham	272 24 35	1742.3	1.08	
			243 40 54	Triangulation-station Sharp	63 43 03	4472.7	2.78	

North side of upper lock-gate, Edwardsburg, Ont.	44 47 04	75 22 43	....	....	....	....	......	Graphically from triangulation-station Stethem.
Triangulation-station Gallops	44 46 37. 61	75 24 22. 66	350 21 16	Triangulation-station Redmill	170 21 30	2613. 5	1. 62	
Triangulation-station Edwardsburg	44 47 30. 14	75 22 50. 12	51 27 09	Triangulation-station Gallops	231 26 04	2601. 1	1. 62	
Triangulation-station Wagner	44 46 26. 19	75 21 48. 59	203 31 55	Triangulation-station Sparrowhawk	23 32 37	3293. 9	2. 05	
			145 34 53	Triangulation-station Edwardsburg	325 34 10	2392. 8	1. 49	
Triangulation-station Redmill	44 45 14. 13	75 24 02. 75	232 58 28	Triangulation-station Wagner	53 00 03	3694. 5	2. 30	
			58 50 26	Triangulation-station Chimney Point.	238 48 20	4603. 7	2. 86	
Triangulation-station Drummond	44 45 00. 15	75 26 28. 17	262 17 57	Triangulation-station Redmill	82 19 40	3227. 4	2. 01	
Triangulation-station Chimney Point.	44 43 56. 92	75 27 01. 81	25 00 32	Triangulation-station 37	205 00 13	1373. 1	0. 85	
Triangulation-station Johnstown	44 44 31. 43	75 28 05. 24	307 21 09	Triangulation-station Chimney Point.	127 21 54	1755. 5	1. 09	
			247 26 48	Triangulation-station Drummond	67 27 56	2311. 7	1. 44	
Triangulation-station 37	44 43 16. 60	75 27 28. 19	47 17 39	Triangulation-station West Base Ogdensburgh.	227 16 39	2564. 4	1. 59	
Triangulation-station Fraser	44 43 35. 09	75 28 49. 50	287 40 57	Triangulation-station 37	107 41 54	1878. 0	1. 17	
			209 14 33	Triangulation-station Johnstown	29 15 04	1993 0	1. 24	
Triangulation-station East Base Ogdensburgh.	44 42 30. 79	75 28 01. 61	152 02 09	Triangulation-station Fraser	332 01 35	2247. 1	1. 40	
			129 16 05	Triangulation-station Windmill	309 15 09	2243. 9	1. 39	
Triangulation-station West Base Ogdensburgh.	44 42 20. 24	75 28 53. 80	254 10 14	Triangulation-station East Base Ogdensburgh.	74 10 51	1194. 0	0. 74	
Triangulation-station 2	44 42 14. 01	75 29 17. 31	249 36 14	Triangulation-station West Base Ogdensburgh.	69 36 31	552. 1	0. 34	
			65 20 35	Triangulation-station Light-house	245 19 51	1514. 7	0. 94	
Triangulation-station Windmill	44 43 16. 80	75 29 20. 55	357 53 24	Triangulation-station 2	177 53 27	1939. 4	1. 21	
			54 09 01	Triangulation-station Henry	234 06 24	6089. 2	3. 78	
Windmill Light-house	44 43 17	75 29 21	....	....	....	....	......	Graphically from triangulation-station windmill.
Triangulation-station Light-house, Ogdensburgh.	44 41 53. 53	75 30 19. 84	206 54 47	Triangulation-station Windmill	26 55 29	2882. 4	1. 79	
			76 04 19	Triangulation-station Railroad	256 02 00	4462. 2	2. 77	
Light-house Peak, Ogdensburgh	44 41 53. 52	75 30 19. 32	....	....	....	....	......	
Triangulation-station Henry	44 41 21. 20	75 33 04. 72	339 10 28	Triangulation-station Nevins	159 10 55	2343. 0	1. 46	
			254 36 42	Triangulation-station Light-house	74 38 38	3764. 6	2. 34	
Triangulation-station Nevins	44 40 10. 24	75 32 26. 90	144 01 32	Triangulation-station Railroad	324 00 43	2610. 5	1. 62	
			221 15 27	Triangulation-station Light-house	41 16 57	4241. 5	2. 64	
Triangulation-station Railroad	44 41 18. 68	75 33 36. 55	38 25 58	Triangulation-station G	218 24 48	3527. 8	2. 19	
Triangulation-station G	44 39 49. 14	75 35 16. 10	260 04 10	Triangulation-station Nevins	80 06 09	3783. 3	2. 35	
			342 08 48	Triangulation-station H	162 09 12	2479. 5	1. 54	
			10 40 28	Triangulation-station I	190 40 04	4023. 0	2. 50	
Triangulation-station I	44 37 41. 05	75 35 49. 91	223 22 07	Triangulation-station H	43 22 55	2191. 9	1. 36	
			49 08 49	Triangulation-station Morristown Point.	229 06 51	4923. 3	3. 06	
Triangulation-station H	44 38 32. 67	75 34 41. 60	69 51 24	Triangulation-station Maitland	249 49 48	3187. 2	1. 98	
			224 33 52	Triangulation-station Nevins	44 35 27	4227. 9	2. 63	
Triangulation-station Maitland	44 37 57. 08	75 36 57. 37	50 07 02	Triangulation-station K	230 06 21	1681. 3	1. 04	
			288 24 17	Triangulation-station I	108 25 05	1567. 1	0. 97	
Triangulation-station K	44 37 22. 15	75 37 55. 90	19 43 06	Triangulation-station Morristown Point.	199 42 36	2802. 5	1. 74	
			258 07 38	Triangulation-station I	78 09 07	2837. 7	1. 76	

Geographical positions—Continued.

SAINT LAWRENCE RIVER SECONDARY TRIANGULATION—Continued.

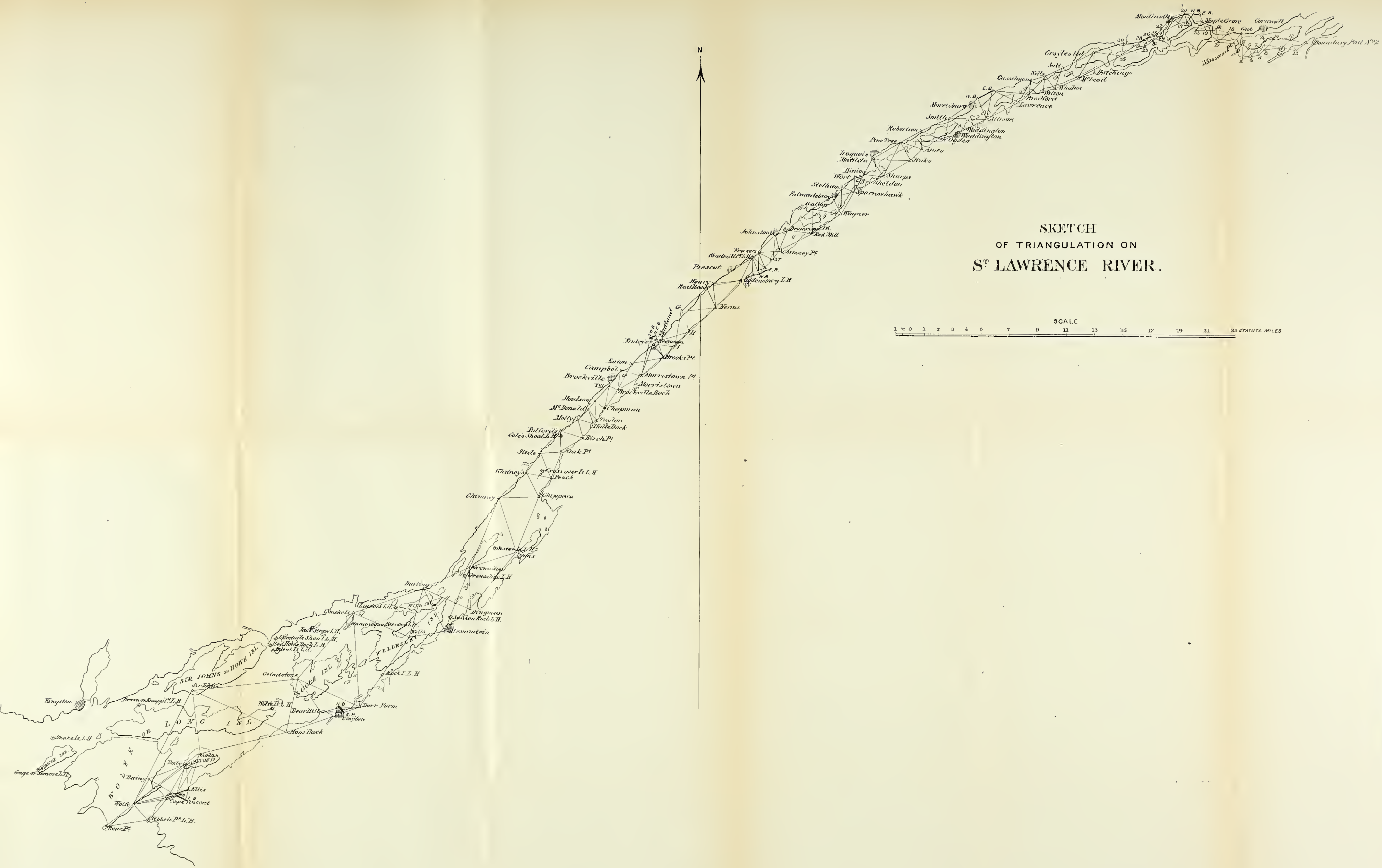
Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back-azimuth.	Distance.	Distance.	Remarks.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Miles.*	
Triangulation-station Morristown Point.	44 35 56. 67	75 38 38. 78	234 26 24	Triangulation-station Brooks	54 27 45	3129. 0	1. 94	
			142 38 15	Triangulation-station Eaton	322 37 47	1444. 9	0. 90	
Corner of bridge, Morristown, N. Y..	44 35 09	75 39 07	....	....	....	....	.....	Southeast corner of bridge graphically from triangulation-station Eaton.
Triangulation-station Brooks Point..	44 36 55. 62	75 36 43. 32	125 46 53	Triangulation-station Finley.........	305 45 50	2420. 3	1. 50	
			117 06 52	Triangulation-station K	297 06 01	1797. 5	1. 12	
			149 43 50	Triangulation-station Brennan.......	329 43 13	2294. 1	1. 43	
Triangulation-station Finley.........	44 37 41. 46	75 38 12. 40	10 11 52	Triangulation-station Morristown Point.	190 11 33	3285. 9	2. 04	
			234 55 46	Triangulation-station Brennan	54 56 12	985. 9	0. 61	
Triangulation-station Brennan.......	44 37 59. 81	75 37 35. 79	81 46 08	Triangulation-station Southwest Base Maitland.	261 45 40	891. 2	0. 55	
			141 22 38	Triangulation-station Northeast Base Maitland.	321 22 32	313. 0	0. 19	
Triangulation-station Southwest Base Maitland.	44 37 55. 67	75 38 15. 81	350 17 12	Triangulation-station Finley.........	170 17 15	445. 2	0. 28	
Triangulation-station Northeast Base Maitland.	44 38 07. 73	75 37 44. 65	61 32 35	Triangulation-station Southwest Base Maitland.	241 32 13	781. 0	0. 49	
Triangulation-station Eaton	44 36 33. 88	75 39 18. 56	258 53 38	Triangulation-station Brooks Point..	78 55 27	3487. 6	2. 17	
			30 06 37	Triangulation-station Brockville Rock.	210 05 37	3728. 5	2. 32	
Triangulation-station Brockville Rock.	44 34 49. 37	75 40 43. 35	232 53 36	Triangulation-station Morrristown Point.	52 55 03	3444. 3	2. 14	
			196 30 52	Triangulation-station Campbell......	16 31 10	1911. 0	1. 19	
Triangulation-station Campbell......	44 35 48. 73	75 40 18. 72	40 39 39	Triangulation-station 21, (A. C. L., 1872.)	220 38 40	2817. 0	1. 75	
			263 38 26	Triangulation-station Morristown Point.	83 39 36	2217. 3	1. 38	
Triangulation-station 21, (A. C. L., 1872.)	44 34 39. 48	75 41 41 92	6 19 22	Triangulation-station Chapman......	186 19 15	2042. 3	1. 27	
			256 42 38	Triangulation-station Brockville Rock.	76 43 19	1327. 6	0. 82	
			35 28 55	Triangulation-station Molson's	215 28 16	2123. 7	1. 32	
Triangulation-station Chapman......	44 33 33. 72	75 41 52. 12	106 36 09	Triangulation-station Molson's......	286 35 37	1051. 6	0. 65	
			213 00 28	Triangulation-station Brockville Rock	33 01 16	2784. 5	1. 73	
			43 52 53	Triangulation-station Taylor	223 52 27	1172. 8	0. 73	

Triangulation-station Molson's	44 33 43.45	75 42 37.79	350 20 19	Triangulation-station Taylor	170 20 25	1162.2	0.72	
			46 10 42	Triangulation-station McDonald	226 10 21	910.1	0.57	
Triangulation-station Taylor	44 33 06.33	75 42 28.95	121 11 31	......do	301 11 04	995.6	0.62	
			40 37 34	Triangulation-station Hall's Dock	220 37 19	751.9	0.47	
Triangulation-station McDonald	44 33 23.03	75 43 07.55	341 33 29	......do	161 33 41	1145.0	0.71	
			54 38 07	Triangulation-station Molly's Gut	234 37 25	1623.2	1.01	
Triangulation-station Hall's Dock	44 32 47.84	75 42 51.13	94 58 44	......do	274 57 50	1692.3	1.05	
			39 29 08	Triangulation-station Birch Point	219 28 24	2171.4	1.35	
Triangulation-station Molly's Gut	44 32 52.59	75 44 07.52	350 28 52	......do	170 29 02	1848.1	1.15	
			54 31 00	Triangulation-station Fullford	234 30 02	2228.1	1.38	
Triangulation-station Birch Point	44 31 53.53	75 43 53.68	104 01 17	......do	284 00 10	2185.0	1.36	
			47 29 00	Triangulation-station Oak Point	227 28 01	2534.6	1.58	
Triangulation-station Fullford	44 32 10.68	75 45 29.71	353 34 35	......do	173 34 44	2256.4	1.40	
			43 22 36	Triangulation-station Slide	223 21 24	3289.5	2.04	
Triangulation-station Slide	44 30 53.19	75 47 12.01	266 35 22	Triangulation-station Oak Point	86 36 42	2516.0	1.56	
			333 24 54	Triangulation-station Peach Island	153 25 35	2906.7	1.81	
			36 43 42	Triangulation-station Whitney	216 42 48	2880.9	1.79	
Triangulation-station Oak Point	44 30 58.03	75 45 18.28	23 47 33	Triangulation-station Peach Island	203 46 54	3003.9	1.87	
Cole's Ferry Light-House	44 31 59	75 45 31	....	....	....	....	......	Graphically from triangulation-station Fullford.
Triangulation-station Peach Island	44 29 28.97	75 46 13.13	95 29 51	Triangulation-station Whitney	275 28 15	3037.6	1.89	
			31 44 26	Triangulation-station Chippewa	211 43 38	2914.2	1.81	
Cross-Over Island Light-House	44 29 49.72	75 46 49.25	....	Triangulation-station Lyons	198 48 22	9360.5	5.82	By triangulation.
				Triangulation-station Chimney	240 03 41	6056.2	3.76	
Triangulation-station Whitney	44 29 38.38	75 48 30.00	331 41 03	Triangulation-station Chippewa	151 41 50	3145.0	1.95	
			48 33 32	Triangulation-station Chimney	228 31 56	4033.7	2.51	
Triangulation-station Chippewa	44 28 08.66	75 47 22.50	91 16 08	.....do	271 13 45	4516.7	2.81	
			21 42 46	Triangulation-station Lyons	201 41 34	6179.3	3.84	
Triangulation-station Chimney	44 28 11.85	75 50 46.82	339 04 05	......do	159 05 16	6251.9	3.89	
			24 25 00	Triangulation-station Grenadier	204 23 00	9165.1	5.70	
Triangulation-station Lyons	44 25 02.64	75 49 05.85	67 25 30	......do	247 22 19	6522.8	4.05	
			38 10 19	Triangulation-station Dingman	218 07 29	8734.2	5.43	
Sister Island Light-House	44 24 51.89	75 50 47.02	....	Triangulation-station Lyons	81 34 00	2262.5	1.41	By triangulation.
				Triangulation-station Dingman	205 45 35	7258.6	4.51	
Triangulation-station Grenadier	44 23 41.42	75 53 38.03	351 47 38	......do	171 47 58	4407.0	2.74	
			65 39 10	Triangulation-station Darling	245 36 08	6309.1	3.92	
Grenadier Island Light-House	44 22 59.36	75 54 25.08	331 23 28	Triangulation-station Dingman	151 24 20	3489.7	2.17	By triangulation.
Triangulation-station Dingman	44 21 20.09	75 53 09.62	105 26 29	Triangulation-station Darling	285 23 08	6615.6	4.11	
Triangulation-station Darling	44 22 17.06	75 57 57.68	325 42 22	Triangulation-station Alexandria	145 44 06	5867.1	3.65	
			15 54 01	Triangulation-station Wells	195 53 08	6044.2	3.76	
			68 34 55	Triangulation-station Smoke	248 30 29	9065.6	5.63	
Triangulation-station Alexandria	44 19 39.98	75 55 28.46	79 00 50	Triangulation-station Wells	258 58 13	5054.8	3.14	
			198 09 20	Triangulation-station Grenadier	18 10 38	7842.5	4.87	
Thousand Islands House	44 20 16.27	75 55 21.53	....	Triangulation-station Darling	317 08 23	5084.6	3.16	By triangulation.
				Triangulation-station Wells	247 47 54	5523.5	3.43	
Sunken Rock Light-House	44 20 45.65	75 55 02.46	15 52 04	Triangulation-station Alexandria	195 51 46	2107.0	1.31	By triangulation.
Triangulation-station Wells	44 19 08.71	75 59 12.41	110 14 03	Triangulation-station Smoke	290 10 29	7230.5	4.49	
			34 08 00	Triangulation-station Dorr Farm	214 05 02	10055.0	6.25	
Lyndock Light-House	44 21 00	76 00 21	....	....	....	....	......	Graphically from triangulation-station Smoke.
Triangulation-station Smoke	44 20 29.62	76 04 18.72	353 54 58	Triangulation-station Dorr Farm	173 55 35	10883.8	6.76	
			37 39 22	Triangulation-station Grindstone	217 36 03	10309.6	6.41	

Geographical positions—Continued.

SAINT LAWRENCE RIVER SECONDARY TRIANGULATION—Continued.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back-azimuth.	Distance.	Distance	Remarks.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Miles.*	
Jack-Straw Light-House	44 19 32.12	76 07 16.79	....	Triangulation-station Smoke	65 47 42	4325.4	2.69	By triangulation.
				Triangulation-station Grindstone	200 09 57	6808.4	4.23	
Gananoque Light-House	44 19 29	76 04 59	....	....	....	....	....	From shore-line co-ordinates.
Triangulation-station Dorr Farm	44 14 38.96	76 03 26.73	109 39 28	Triangulation-station Grindstone	289 35 33	7912.5	4.92	
			58 00 36	Triangulation-station Hogsback	237 56 34	9067.8	5.63	
Rock Island Light-House	44 16 50	76 01 07	....	....	....	....	....	Graphically from triangulation-station Wells.
Triangulation-station Bear Hill	44 14 02.88	76 06 46.49	141 18 08	Triangulation-station Grindstone	321 16 33	4832.3	3.00	
Triangulation-station Grindstone	44 16 05.06	76 09 02.73	1 46 10	Triangulation-station Hogsback	181 46 03	7469.5	4.64	
			81 35 23	Triangulation-station Sir John	261 28 40	12937.8	8.04	
Marvin's Island Light-House	44 17 48	76 11 36	....	....	....	....	....	From shore-line co-ordinates.
Wesleyan Church, Gananoque, Ontario	44 19 42	76 10 13	....	....	....	....	....	Graphically.
Triangulation-station Hogsback	44 12 03.16	76 09 13.12	113 54 52	Triangulation-station Sir John	293 48 16	13748.5	8.54	
			80 17 22	Triangulation-station Carlton	260 11 27	11502.7	7.15	
Triangulation-station Sir John	44 15 03.35	76 18 39.70	350 35 25	do	170 36 04	7613.5	4.73	
Wolfe Island Light-House	44 14 20.68	76 11 09 97	....	Triangulation-station Grindstone	41 14 03	4283.1	2.66	By triangulation.
Brown's Point Light-House	44 13 57	76 24 00	....	....	....	....	....	From shore-line co-ordinates.
Roman Catholic church, Clayton	44 14 19.85	76 05 17.21	....	Triangulation-station Bear Hill	255 11 36	2049.1	1.27	By triangulation.
Triangulation-station Carlton	44 10 59.98	76 17 43.65	....	....	....	....	....	


SKETCH
OF TRIANGULATION ON
S^T LAWRENCE RIVER.
SCALE
STATUTE MILES
N
Kingston
Cornwall
Maple Grove
Boundary Post No. 2
Massena Pt.
Crysler's Isl.
Jutt
Wells
Casselman
Hutchings
McLeod
Whalen
Wilson
Bradford
Lawrence
Morrisburg
Smith
Allison
Robertson
Waddington
Ogden
Pine Tree
Ames
Iroquois
Matilda
Jinks
Sharps
Sheldon
Stetham
Sparrowhawk
Edwardsburg
Gallop
Wagner
Johnstown
Red Mill
Chimney Pt.
Prescott
Ogdensburg L.H.
Yerms
Brooks Pt.
Eaton
Campbel
Brockville
Morristown Pt.
Morristown
Brockville Rock
Moulson
McDonald
Chapman
Molly
Taylor
Halls Dock
Coles Shoal L.H.
Birch Pt.
Slide
Oak Pt.
Whitneys
Cross over Is. L.H.
Peach
Chimney
Cappara
Lyons
Grenadier
Grenadier L.H.
Darling
Dingman
Sunken Rock L.H.
Alexandria
Snake Is.
Jack Straw L.H.
Spectacle Shoal L.H.
Wells
WELLESLEY ISL.
HILL ISL.
Grindstone
GORE ISL.
Rock I. L.H.
SIR JOHNS OR HOWE ISL.
Sir Johns
Wolfe Is. L.H.
Bear Hill
Clayton
Dorr Farm
LONG ISL.
Hogs Back
Snake Is. L.H.
Gage or Simcoe L.H.
WOLFE
Rainy
Daly
CARLTON IS.
Carlton
Ellis
Wolfe
Cape Vincent
Tibbets Pt. L.H.
Bear Pt.

APPENDIX L.—METEOROLOGICAL OBSERVATIONS.

REPORT OF MR. O. B. WHEELER, ASSISTANT ENGINEER.

OFFICE UNITED STATES LAKE-SURVEY,
Detroit, Mich., June 29, 1876.

GENERAL: I have the honor herewith to submit the results of the reductions of the observations made at the three meteorological stations Port Austin and Monroe, Mich., and Sacket's Harbor, New York, for the years 1874 and 1875. The tables give:

1. The number of observations of wind from the different points of the compass, and also the total number for months and year.
2. The resultant direction of the wind for each month, season, and for the year.
3. The maximum, minimum, and mean barometrical pressure for each month and season and for the year, reduced to 32° Fahrenheit, but uncorrected for elevation. The barometers remain at the same elevations, respectively, as reported in the annual report for 1872.
4. The maximum, minimum, and mean temperature for each month and season and for the year.
5. The mean amount of cloudiness for months, seasons, and the year.
6. The total amount of rain or melted snow for months, seasons, and for the year.
7. The mean amount of humidity for months, seasons, and the year.

PORT AUSTIN, MICH.

Number of observations of wind from different points of compass.

1874.	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm.	No. of observations.
January	9	9	0	6	12	22	9	21	4	92
February	10	10	5	7	8	17	13	11	2	83
March	6	5	4	15	1	17	13	29	2	92
April	10	20	11	6	6	16	5	11	3	88
May	11	24	7	5	8	8	14	11	2	90
June	4	10	8	12	13	13	18	6	5	89
July	14	16	4	2	12	16	15	5	3	87
August	6	26	17	9	8	3	12	3	4	88
September	4	9	7	10	11	20	16	10	1	88
October	3	14	6	6	14	20	4	23	2	92
November	2	2	0	7	9	25	14	26	2	87
December	8	3	0	4	16	28	22	11	1	93
Sum	87	148	69	89	118	205	155	167	31	1,069

1875.	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm.	No. of observations.
January	4	2	0	3	18	27	18	12	5	89
February	3	8	0	5	10	26	16	13	3	84
March	9	22	4	12	6	10	20	1	6	90
April	17	13	8	7	6	9	12	10	5	87
May	12	16	11	10	5	12	9	10	3	88
June	7	14	23	5	8	12	10	4	5	88
July	9	19	6	5	11	12	16	6	2	86
August	8	10	5	8	18	21	11	8	3	92
September	5	14	5	7	12	15	4	17	1	80
October	8	11	4	5	12	19	10	18	2	89
November	2	16	4	9	9	22	4	19	0	85
December	3	5	8	15	13	17	8	18	2	89
Sum	87	150	78	91	128	202	138	136	37	1,047

MONROE, MICH.

Number of observations of wind from different points of compass.

1874.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.	No. of observations.
January	4	12	4	7	13	22	7	13	5	87
February	7	21	5	1	10	21	14	3	2	84
March	3	18	3	5	7	31	8	16	2	93
April	17	23	12	10	4	9	4	7	4	90
May	12	19	5	10	8	14	9	7	9	93
June	5	12	15	10	3	19	7	8	11	90
July	6	14	7	12	14	24	2	5	9	93
August	7	28	13	13	7	12	2	1	10	93
September	9	21	5	9	8	18	6	6	8	90
October	8	16	6	4	5	27	3	12	12	93
November	11	8	1	3	15	25	12	7	8	90
December	7	8	3	0	22	25	8	3	9	85
Sum	96	200	79	84	116	247	82	88	89	1,081

1875.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.	No. of observations.
January	9	7	10	1	5	37	15	3	6	93
February	5	12	4	3	8	13	21	10	8	84
March	5	18	18	7	0	17	13	6	9	93
April	7	15	15	7	4	11	17	5	9	90
May	11	14	14	10	5	11	15	1	12	93
June	4	15	9	5	8	28	5	6	10	90
July	6	19	2	12	7	21	5	6	15	93
August	8	16	0	11	3	27	5	8	15	93
September	4	12	1	6	6	29	12	5	15	90
October	7	11	5	6	6	29	9	10	10	93
November	14	21	4	4	11	16	2	10	8	90
December	2	18	10	11	4	35	7	4	2	93
Sum	82	178	92	83	67	274	126	74	119	1,095

SACKET'S HARBOR.

Number of observations of wind from different points of compass.

1874.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.	No. of observations.
January	4	32	4	1	25	14	4	9	0	93
February	5	27	3	5	11	9	10	10	4	84
March	8	12	1	1	20	11	16	21	3	93
April	4	27	3	2	8	12	21	7	5	89
May	5	17	4	1	18	24	12	6	5	92
June	1	20	4	3	21	28	10	2	1	90
July	1	19	4	5	32	21	8	0	2	92
August	4	14	8	7	24	12	11	0	6	86
September	7	10	7	4	35	16	4	3	1	87
October	7	10	5	2	21	11	18	6	1	81
November	4	5	1	1	4	6	6	5	1	33
December	4	22	3	2	24	13	12	9	3	92
Sum	54	215	47	34	243	177	132	78	32	1,012

1875.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.	No. of observations.
January	7	29	4	7	19	5	9	9	4	93
February	2	12	2	2	24	4	17	19	2	84
March	6	24	4	1	18	14	20	4	2	93
April	7	21	4	1	20	11	21	3	2	90
May	2	8	6	6	17	23	23	4	4	93
June	1	7	5	1	26	28	16	3	3	90
July	2	7	1	2	29	22	24	4	1	92
August	2	11	12	7	25	20	10	1	5	93
September	5	18	3	5	15	19	17	4	0	86
October	6	24	1	1	26	11	20	4	0	93
November	7	27	3	3	18	8	10	13	0	89
December	6	36	1	1	26	10	6	6	1	93
Sum	53	224	46	37	263	175	193	74	24	1,089

Resultant direction of the wind for each month and season, and for the year 1874.

Months, seasons, and year.	Port Austin.	Monroe.	Sacket's Harbor.
MONTHS.			
January	N. 38° W.	S. 41° W.	S. 35° W.
February	N. 78° W.	S. 81° E.	S. 73° W.
March	N. 55° W.	S. 71° W.	North.
April	N. 4° W.	N. 15° E.	N. 80° W.
May	N. 10° E.	S. 81° E.	S. 63° W.
June	S. 82° W.	S. 9° W.	S. 42° W.
July	N. 13° W.	S. 14° W.	S. 22° W.
August	N. 48° E.	S. 82° E.	S. 31° W.
September	N. 35° W.	S. 3° W.	S. 21° W.
October	N. 48° W.	S. 67° W.	S. 74° W.
November	N. 68° W.	S. 55° W.	S. 87° W.
December	N. 71° W.	S. 39° W.	S. 73° W.
SEASONS.			
Spring	N. 31° W.	S. 39° E.	S. 85° W,
Summer	N. 7° E.	S. 32° E.	S. 32° W.
Autumn	N. 49° W.	S. 55° W.	S. 60° W.
Winter of 1873 and 1874	S. 69° W.	S. 25° W.	S. 57° W.
YEAR.			
1874	N. 41° W.	S. 21° W.	S. 61° W.

Resultant direction of the wind for each month and season, and for the year 1875.

Months, seasons, and year.	Port Austin.	Monroe.	Sacket's Harbor.
MONTHS.			
January	N. 82° W.	S. 52° W.	S. 72° W.
February	S. 74° W.	S. 81° W.	S. 85° W.
March	N. 59° W.	S. 78° W.	S. 49° W.
April	N. 48° W.	N. 77° W.	S. 66° W.
May	N. 11° E.	N. 65° E.	S. 65° W.
June	N. 8° W.	S. 30° W.	S. 51° W.
July	N. 11° W.	S. 56° W.	S. 64° W.
August	N. 10° W.	S. 51° W.	S. 39° W.
September	N. 15° W.	S. 73° W.	S. 69° W.
October	N. 37° W.	S. 65° W.	S. 53° W.
November	N. 54° W.	N. 14° W.	S. 79° W.
December	N. 55° W.	S. 37° W.	S. 35° W.
SEASONS.			
Spring	N. 16° W.	N. 87° W.	S. 61° W.
Summer	N. 10° W.	S. 37° W.	S. 52° W.
Autumn	N. 32° W.	S. 69° W.	S. 66° W.
Winter of 1874 and 1875	N. 86° W.	S. 60° W.	S. 88° W.
YEAR.			
1875	N. 39° W.	S. 64° W.	S. 62° W.

Maximum, minimum, and mean barometrical pressure for each month and season, and for the year 1874.

Months, seasons, and year.	Port Austin. Maximum.	Port Austin. Minimum.	Port Austin. Mean.	Monroe. Maximum.	Monroe. Minimum.	Monroe. Mean.	Sacket's Harbor. Maximum.	Sacket's Harbor. Minimum.	Sacket's Harbor. Mean.
MONTHS.									
January	30.016	28.752	29.387	30.072	28.897	29.429	30.352	29.172	29.778
February	29.949	28.680	29.449	29.917	28.751	29.456	30.452	29.206	29.830
March	29.795	28.662	29.322	29.788	28.749	29.361	30.178	29.006	29.640
April	29.932	28.868	29.408	29.945	28.908	29.411	30.211	29.231	29.727
May	29.611	28.708	29.327	29.541	28.892	29.338	30.031	29.103	29.623
June	29.644	28.858	29.317	29.636	28.968	29.314	29.987	29.295	29.641
July	29.554	29.030	29.342	29.565	29.141	29.346	29.875	29.406	29.663
August	29.693	29.082	29.399	29.603	29.057	29.386	29.965	29.266	29.731
September	29.603	29.042	29.398	29.600	29.166	29.406	30.032	29.220	29.763
October	29.886	28.705	29.415	29.852	28.955	29.432	30.140	29.174	29.726
November	29.901	28.170	29.381	29.886	28.388	29.426	30.166	28.772	29.585
December	30.095	28.892	29.400	30.051	29.060	29.449	30.502	29.342	29.778
SEASONS.									
Winter 1873–'74	30.016	28.654	29.416	30.072	28.751	29.443	30.452	29.153	29.793
Spring	29.611	28.662	29.352	29.945	28.749	29.370	30.211	29.006	29.663
Summer	29.554	28.858	29.353	29.636	28.986	29.349	29.987	29.266	29.678
Autumn	29.603	28.170	29.398	29.886	28.388	29.421	30.166	28.772	29.691
YEAR.									
1874	30.095	28.170	29.379	30.072	28.388	29.396	30.502	28.772	29.707
Range		1.925			1.684			1.730	

Maximum, minimum, and mean barometrical pressure for each month and season, and for the year 1875.

Months, seasons, and year.	Port Austin. Maximum.	Port Austin. Minimum.	Port Austin. Mean.	Monroe. Maximum.	Monroe. Minimum.	Monroe. Mean.	Sacket's Harbor. Maximum.	Sacket's Harbor. Minimum.	Sacket's Harbor. Mean.
MONTHS.									
January	29.829	28.998	29.469	29.839	29.145	29.513	30.342	29.193	29.841
February	29.934	28.580	29.345	29.961	28.795	29.417	30.262	29.076	29.719
March	29.783	28.407	29.332	29.763	28.522	29.348	30.136	29.048	29.755
April	29.849	28.527	29.316	29.751	28.725	29.303	30.162	29.046	29.663
May	29.827	28.697	29.302	29.782	28.615	29.294	29.992	29.119	29.632
June	29.632	29.035	29.337	29.494	29.135	29.328	29.938	29.400	29.671
July	29.778	29.044	29.346	29.641	29.113	29.339	29.997	29.400	29.655
August	29.772	28.792	29.332	29.687	28.925	29.337	30.084	29.401	29.714
September	29.764	28.934	29.367	29.717	29.007	29.380	30.142	29.220	29.694
October	29.751	28.492	29.278	29.797	28.933	29.314	30.152	29.118	29.641
November	29.945	28.882	29.421	29.902	28.914	29.382	30.342	29.134	29.759
December	29.720	28.579	29.235	29.742	28.742	29.249	30.270	28.835	29.636
SEASONS.									
Spring	29.849	28.407	29.317	29.782	28.522	29.315	30.162	29.046	29.683
Summer	29.778	28.772	29.338	29.687	28.925	29.335	30.084	29.400	29.680
Autumn	29.945	28.492	29.355	29.902	28.914	29.359	30.342	29.118	29.698
Winter 1874–'75	30.095	28.580	29.405	30.051	28.795	29.460	30.502	29.076	29.779
YEAR.									
1875	30.095	28.407	29.340	30.051	28.522	29.350	30.502	28.835	29.698
Range		1.688			1.529			1.667	

Maximum, minimum, and mean temperature for each month and season, and for the year 1874.

Months, seasons, and year.	Port Austin.			Monroe.			Sacket's Harbor.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
MONTHS.									
January	54	6	26.8	63	— 6	28.5	63	— 22	24.0
February	48	5	26.2	57	6	28.0	47	— 27	20.0
March	54	9	31.1	70	12	34.6	59	— 2	28.9
April	57	7	34.4	75	12	38.9	59	7	34.0
May	86	33	53.9	92	27	60.0	79	24	53.0
June	96	43	67.7	98	42	71.7	87	40	62.5
July	98.5	55	70.8	104.5	52	74.6	90	50	69.0
August	92	51	69.2	99	49	72.7	94	41	66.7
September	86	47	67.0	95	35	68.3	90	36	64.7
October	69	29	51.7	75	19	52.4	66	34	48.3
November	65	16	39.1	67	0	38.6	50	4	29.7
December	48	10	27.7	55	— 2	28.7	47	— 29	23.6
SEASONS.									
Spring	86	7	39.8	92	12	44.5	79	— 2	38.6
Summer	98.5	43	69.2	104.5	42	73.0	94	40	66.1
Autumn	86	16	52.6	95	0	53.1	90	4	47.6
Winter of 1873–74	56	5	28.1	63	— 6	29.3	63	— 27	24.3
YEAR.									
1874	98.5	5	47.1	104.5	— 6	49.7	94	— 29	43.7
Range	91			110.5			123		

Maximum, minimum, and mean temperature for each month and season and for the year 1875.

Months, seasons, and year.	Port Austin.			Monroe.			Sacket's Harbor.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
MONTHS.									
January	33	— 8	15.8	40	— 17	15.3	35	— 18	13.2
February	......	....	9.5	54	— 20	13.5	47	— 32	11.2
March	60	3	25.1	76	— 6	28.6	62	— 17	24.5
April	64	13	37.2	71	7	41.2	65	13	36.4
May	78	31	53.3	90	30	58.4	78	26	51.1
June	90	41	64.0	95	42	69.5	88	40	63.2
July	91	53	70.6	92	52	72.1	83	45	67.8
August	84	53	68.5	86	44	68.6	85	45	68.5
September	90	40	60.5	92	35	61.5	87	30	57.9
October	72	29	45.8	75	20	47.0	69	25	45.5
November	53	8	33.4	63	4	33.9	57	— 18	30.6
December	69	5	31.8	67	1	33.9	63	— 31	25.9
SEASONS.									
Spring	78	3	38.5	90	— 6	42.7	78	— 17	37.3
Summer	91	41	67.7	95	42	70.1	88	40	66.5
Autumn	90	8	46.6	92	4	47.5	87	— 18	44.7
Winter of 1874–75	48	— 8	17.7	55	— 20	19.2	47	— 32	16.0
YEAR.									
1875	91	— 8	43.0	95	— 20	45.3	88	— 32	41.3
Range	99			115			120		

Mean amount of cloudiness from 0 (clear sky) to 10 for months, seasons, and year, for the years 1874 and 1875.

Stations.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Spring.	Summer.	Autumn.	Winter.	Year.
1874.																1873, 1874	
Port Austin	7.3	7.1	4.0	3.3	3.1	2.9	2.0	1.3	2.6	5.7	6.2	7.2	3.5	2.1	4.8	7.1	4.4
Monroe	6.3	5.8	4.1	4.8	3.5	4.0	3.6	2.8	3.5	3.6	4.7	4.8	4.1	3.5	3.9	6.2	4.3
Sacket's Harbor	7.5	6.2	7.1	6.6	5.9	6.7	5.8	4.3	5.5	7.3	8.5	8.0	6.5	5.6	7.1	7.3	6.6
1875.																1874, 1875	
Port Austin	6.0	4.1	3.2	4.4	3.4	2.0	1.3	2.6	3.8	6.5	7.2	7.4	3.7	2.0	5.8	5.8	4.3
Monroe	4.8	4.2	4.6	4.4	4.3	4.5	4.1	4.2	4.3	5.2	4.7	5.9	4.4	4.3	4.7	4.6	4.6
Sacket's Harbor	7.2	6.3	5.8	6.2	5.4	5.6	4.4	5.3	6.0	7.4	7.5	7.9	5.8	5.1	7.0	7.2	6.3

Total amount of rain or melted snow in inches for months, seasons, and year for the years 1874 and 1875.

Stations.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Spring.	Summer.	Autumn.	Winter.	Year.
1874.																1873, 1874.	
Port Austin	2.34	0.78	0.98	0.71	2.85	......	2.05	0.60	1.37	1.18	0.31	0.55	1.51	0.88	0.95	1.43	1.25
Monroe	3.86	2.99	1.40	1.56	1.11	1.64	1.33	0.78	0.32	0.34	2.28	0.45	1.36	1.25	0.98	3.75	1.51
Sacket's Harbor	5.78	2.68	2.70	2.42	1.28	2.38	3.58	1.38	2.70	3.64	2.30	2.04	2.13	2.45	2.88	3.72	2.74
1875.																1874, 1875	
Port Austin	0.77	1.42	1.83	1.40	3.95	2.02	0.99	1.38	2.21	4.02	1.25	2.58	2.39	1.46	2.49	0.91	1.99
Monroe	1.39	1.82	4.38	0.60	2.97	3.61	2.12	3.65	3.65	1.83	1.26	1.76	2.65	3.13	2.25	1.22	2.42
Sacket's Harbor	2.40	3.46	2.08	1.54	3.28	1.72	1.94	2.78	2.76	3.20	2.00	1.98	2.30	2.15	2.65	2.63	2.43

Mean amount of humidity for months, seasons, and year (saturation 1,000) for the years 1874 and 1875.

Stations.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Spring.	Summer.	Autumn.	Winter.	Year.
1874.																1873, 1874	
Port Austin	.799	.789	.756	.716	.688	.694	.691	.710	.712	.705	......	.803	.720	.698	.709	.792	.733
Monroe	.784	.755	.724	.652	.661	.666	.704	.675	.665	.667	.666	.728	.679	.682	.666	.768	.695
Sacket's Harbor	.697	.699	.723	.714	.663	.732	.729	.697	.703	.738	.722	.698	.700	.719	.721	.720	.710
1875.																1874, 1875	
Port Austin	.633	.598	......	.769	.703	.697	.704	.761	.752	.840	.931	......	.736	.721	.841	.678	.739
Monroe	.784	.776	.694	.646	.635	.674	.703	.719	.721	.717	.728	.722	.658	.699	.722	.763	.710
Sacket's Harbor	.661	.641	.735	.761	.685	.681	.701	.706	.688	.719	.726	.764	.727	.696	.711	.667	.706

Very respectfully, your obedient servant,

O. B. Wheeler,
Assistant Engineer.

General C. B. Comstock,
Superintendent United States Lake-Survey.

APPENDIX M.—FIELD AND OFFICE WORK.

1.—REPORT OF CAPTAIN H. M. ADAMS, CORPS OF ENGINEERS.

DETROIT, MICH., *June* 7, 1876.

MAJOR: I have the honor to submit the following report in regard to the work done by myself, and by parties under my direction, during the year ending May 1, 1876.

By your order of May, 1875, I was directed to take charge of the off-shore hydrography in Lake Ontario and to supply and move the shore-parties of Assistant Engineers Mayer, Lamson, Towar, Terry, and Eisenmann.

This work was to be performed with the steamers Ada and Surveyor; the former commanded by myself and the latter in charge of Lieut. C. F. Powell.

I left Detroit with the Ada May 4, 1875, arrived at Oswego May 7, and finished the distribution of shore-parties, provisions and camp-equipage May 13.

The marking-stones for triangulation-station Houston were placed and located.

A shoal was located and sounded out near Kingston.

Off-shore hydrography was commenced at Oswego and was continued west to Pultneyville by Lieutenant Powell, with the Surveyor, from Pultneyville to Sandy Creek by myself with the Ada; from Sandy Creek to a point 5 miles west of Port Dalhousie by Lieutenant Powell.

The soundings south and west of the Duck Islands, from South Bay Point to Galloo Island, were completed; a shoal was located 1½ miles south-southeast from South Bay Point; and the long lines of soundings across the lake were completed by myself with the Ada, July 30.

Off-shore work was next commenced in Lake Erie, at Morgan's Point, 5 miles west of Port Colborne. This work was continued east to Buffalo, and from Buffalo west to Dunkirk, with the Ada; from Dunkirk to Erie with the Surveyor, and from Erie to Conneaut with the Ada and Surveyor, but not including the sounding of a length of 5 miles from triangulation station 30 to triangulation station 5.

A shoal was located near Stugeon Point, and the hydrography around Long Point, on the north and south sides, west to the meridian 5 miles west of the light-house, was also completed by the party on the Ada.

The shore parties were supplied with provisions and implements, and were moved from one camp to another until the shore-line work was completed to a point 4 miles east of Conneaut, Ohio, October 13, 1875.

Field-work was then suspended for the season, the small boats and camp-equipage belonging to the shore-parties was stowed at Erie, Pa., and the steamers returned to Detroit.

In the office, I have been engaged in plotting the hydrography executed by the party in my charge, in examining and verifying the shore-line work, topography and hydrography, executed in 1874 and 1875, and in collecting and reducing data for a magnetic chart of the lakes.

In plotting soundings, I was assisted by Mr. C. W. Walton.

Very respectfully, your obedient servant,

H. M. ADAMS,
Captain of Engineers.

To Major C. B. COMSTOCK,
In charge survey of Northern and Northwestern Lakes.

2.—REPORT OF LIEUTENANT CHAS. F. POWELL, CORPS OF ENGINEERS.

OFFICE OF SURVEY OF N. AND N. W. LAKES,
Detroit, Mich., June 15, 1876.

MAJOR: I have to submit the following report of my work on the survey for the preceding year.

During the field-season I was in command of the lake-survey steamer Surveyor, and engaged on hydrographic work. I left Detroit April 19, 1875, for Sacket's Harbor, N. Y., where the Surveyor had been wintered, to fit her out for the summer's work.

Off-shore sounding was commenced May 20, near Oswego, N. Y., connecting with Lieutenant Bailey's work of 1874. A marked discrepancy was noticed throughout the record of the day's work, between the depths given by the sounding apparatus and lead-line. The apparatus is Walker's patent indicator, No. 1070. The line, Russian hemp, 1⅝ inches, was new, but had been soaked and stretched before being marked, and was measured at the time of sounding. Careful tests of the indicator were made during the following days under favorable and different circumstances; they showed that the indicator-readings were too small for depths from 20 fathoms to the deepest water sounded, and that the corrections were functions of the depths, but somewhat

variable ones. It was therefore determined for the summer's work to rely on the lead-line, but to note the indicator-readings for application in the cases where true soundings by the line might be lost. With this intention in view, the line was thereafter measured during each day's work, care observed in getting depths by it, in keeping the indicator and line in the same condition when in use, and in throwing the lead and paying out the line in the same way.

After the conclusion of the experiments in sounding, the off-shore hydrography was recommenced and carried to Pultneyville, N. Y., joining with the work of the lake-survey steamer Ada, in command of Capt. H. M. Adams. By direction of that officer the sounding was taken up again at Sandy Creek, N. Y., and carried continuously 5 miles west of Port Dalhousie, Ontario; this point is the westerly end of the shore-line survey on Lake Ontario, and was reached by the steamer July 30.

The Surveyor's work had extended along a shore-front of 114.5 miles; 1,995 soundings were made, 88 per cent. of which were located instrumentally. The deepest water found, the limit of the work being 10 or nearly 10 miles from shore, was 113 fathoms. That depth was obtained at the outer end of a line 3 miles east of Pultneyville. Ford Shoals, near Oswego, were surveyed, and careful and extended search was made for the shoals indicated on the Canadian charts as existing, one 5 miles off a point midway between Big and Little Sodus Bays, and another 4 miles off Devil's Nose. Thirty fathoms, with sand and clay bottom, were found at the first locality, and 55 fathoms, with clay, at the other; and at both places the slope of the lake-bottom is ordinarily regular between the outer limits of in-shore and off-shore hydrography.

After the termination of the Lake Ontario work the Surveyor was taken to Lake Erie. Seventeen days were occupied in going up the Welland Canal, on account of the necessity for extensive changes in the steamer to permit her passage through the smaller locks and the consequent refitting. During this delay the final plotting was made of the off-shore hydrography along the shore-line run west of Oswego in 1874; also, the tabulation was then commenced, and completed before the end of the season, of the comparisons of indicator and lead-line readings. These comparisons are separated into two series by a change made in the indicator, which permitted the propeller to revolve more easily in depths of 30 fathoms and more. The ratio of the readings of the indicator and line in each comparison was used to find what depth would correspond to the nearest multiple of 5 fathoms on the indicator. The mean values of the indicator-corrections at the different multiples were combined to find the run, and a table of resulting corrections filled out. The average number of comparisons in the groups of the first series is 48, and of the second 21, the readings ranging in both from 20 to 85 fathoms, inclusively. The individual corrections in each group rarely differed from the mean more than 2 fathoms, and were generally less than 1 fathom. The greatest difference between the mean and true lines, representing indicator-values, is at 60 fathoms in both series; the difference is 0.6 in the first and 0.8 fathoms in the second series. In the first series the mean corrections at 20 and 85 fathoms' readings are +0.5 and +13.6 fathoms respectively; and for the same readings in the second series, +0.5 and +9.6 fathoms. The tabulation is given in note-book O, 185. Nearly 200 indicator-readings, distributed throughout the Lake Ontario work, were corrected by the above method.

In Lake Erie the Surveyor sounded from Dunkirk, N. Y., to Erie, Pa., 45 miles, and from Conneaut, Ohio, east 13.5 miles. The work from Dunkirk to Erie was done between August 22 and September 15; the Conneaut portion from the latter date to October 9; 1,330 soundings were made, and 93 per cent. of them located instrumentally. No depths exceeding 25 fathoms were obtained, and all were read with a lead-line. The steamer was in advance of the shore-parties. The charts for field-plotting were made by means of a triangulation carried along by observations with a sextant on board and theodolites on land.

The Surveyor arrived at Detroit October 14 and was laid up for the winter.

During the office-season I made the duplicate computations of Lieutenant Price's time-work, and partly of Lieutenant Lockwood's for longitude of primary stations, and verified the final charts of my field-work. In addition, work at the dock and on the steamers, extending at different times throughout the winter and spring, was in my charge.

Very respectfully, your obedient servant,

CHAS. F. POWELL,
First Lieutenant of Engineers.

To Maj. C. B. COMSTOCK,
In charge of survey of Northern and Northwestern Lakes.

3.—REPORT OF MR. O. B. WHEELER, ASSISTANT ENGINEER.

OFFICE UNITED STATES LAKE SURVEY,
Detroit, Mich., June 26, 1876.

GENERAL: I have the honor to submit the following abstract of work accomplished to date by the computing division since May 1, 1875. All computations not self-checking have been duplicated.

1. *Triangulation.*—The adjustment by least squares of primary triangulation from line Vulcan–Huron Mountains, on Lake Superior, to line Warren–Fremont, near Chicago, Ill., in four sets of equations; an adjustment of triangulation from Minnesota base to line Split-Rock–Detour on Lake Superior, in one set of equations; a nearly completed adjustment of Lake Ontario triangulation from Sandy Creek base to line Tonawanda–Pekin, near Buffalo base, in one set of equations. The method employed is that given in the Lake Survey Report for 1872. The preliminary computation of primary triangulation of Lake Ontario and computation of secondary triangulation connecting primary triangulation with shore-line work through fifteen stations along shore, at intervals of approximately ten miles.

2. *Geodetic positions.*—The computation of seventy-five geodetic positions on Saint Lawrence River; the determination of ninety geodetic positions on Lake Ontario for mapping purposes; the tabulation for publication of one hundred and forty-five geodetic positions on Saint Lawrence River.

3. *Data for reduced charts.*—The referring of sixty-eight stations on Saint Lawrence River to meridians and parallels, 3′ apart; forty-seven stations on the east end of Lake Ontario to meridians and parallels, 10′ apart; twenty-eight stations on Lake Michigan to meridians and parallels, 5′ apart; and of fifty-four stations on Lake Ontario to meridians and parallels, 30′ apart. The preparation of tables and notes for eight final charts.

4. *Latitude and longitude.*—The check-computation of latitude of eleven stations in the States of New York, Ohio, and Michigan, and of the triangulation connecting the astronomical stations with fixed points of reference. The making of observations at Detroit and their reduction for the difference of longitude between Detroit, Mich., and Fort Richardson, Texas.

5. *Water-levels.*—The reduction, from original registers, of water-level observations made since June, 1859, and preparation for publication of tables of results, platting of curves, and description of bench-marks. The examination of zeros of gauges and bench-marks at twelve stations and the reduction of leveling-notes made at these stations.

6. *Meteorology.*—The reduction of two years' observations at each of three stations, and tabulation for publication of the results.

7. *Miscellaneous.*—The comparing, tabulating, and putting in form the results from all computations. The reading of proof-sheets of the last annual report. The examination of projections for eight reduced charts and a final examination of five finished within the year. The check-computation of the expansion of the Clarke yards from fifty equations of condition, for the first power of temperature and for the first and second powers of temperature. The determination of the value of one revolution of the screw of the level-trier and the determination of the values of two levels. The review of copies of field-notes as received and a computation of the triangulation and target corrections. Writing up a description of triangulation-stations occupied within the year. The compiling of six progress-sketches showing completed and proposed lake-survey charts, systems of triangulations, &c., and two index-charts showing limits of detail-charts. The computation of fifty-one apparent places of slow stars. The examination of forty-five office reports on latitude-work, to find from residual errors those stars in Safford's Catalogue of 981 Stars, whose declinations are considerably in error. The corrections of the standard chronometers were found at intervals of two weeks, and the necessary time-observations made when not done by other parties.

All the chronometers were wound daily. Various other check-computations have been made and data looked up and furnished parties as occasion required. I have been faithfully assisted by Assistant Engineers Wright, Kummell, Polhemus, and Morrison regularly, and by Assistant Engineers T. Russell, Metcalf, Darling, L. L. Wheeler, Lehnartz, Ockerson, Teeple, and Morrow, and Mr. Church, while assigned to me.

Very respectfully, your obedient servant,

O. B. WHEELER,
Assistant Engineer.

General C. B. COMSTOCK,
Superintendent United States Lake Survey.

4.—REPORT OF MR. E. S. WHEELER, ASSISTANT ENGINEER.

OFFICE UNITED STATES LAKE SURVEY,
May 1, 1876.

SIR: I have the honor to report the following work done under my charge during the past year.

In May and June I was engaged in determining the rate of expansion of the lake-survey standards, and have submitted a special report upon the apparatus used and the results obtained.

During July I was engaged in comparing the lake-survey standards with each other. In all of this work I was aided by Assistant Engineer Pratt.

On the 7th of August I left by steamer for Buffalo, accompanied by Assistant Engineer Russel and having in charge the entire primary-base apparatus. Assistant Engineer Olds joined the party at Erie.

The instruments and party arrived at the Buffalo base-line August 9. This base lies east of Buffalo and about 6 miles from Lake Erie. Its entire length is through cultivated fields. The usual arrangements for comparisons were made.

The work was done in the manner described for the Sandy Creek base in last year's report.

Assistant Engineer Pratt joined the party August 26 and aided in all the comparisons. Assistant Engineer Olds set out the line-stakes.

There are twelve marking-stones on this base. All have the letters U. S. and the usual marking-brasses in their upper surfaces.

At the east end there are three stones set so that the line passing through them is approximately at right angles to the base-line. Their tops are 4 feet below the surface of the ground; their length is 5 feet and their cross-section 8 inches square. The middle one marks the east end of the line. The north one is 11.99 feet and the south one 12.66 feet from the middle one.

At the west end there are also three stones of the same dimensions and set in the same manner. The middle one marks the west end of the line. The north one is 12.17 feet and the south one 12.07 feet from the middle one.

The middle stone is 4,981 feet west of the west end of the 1483d tube. This fractional tube occurs because the west-base station was marked and used for triangulation before the base was measured. Near the middle of the line (9.66 feet west of the west end of 760th tube) there is another stone 5 feet long, with its top 4 feet below the surface of the ground. This stone marks the middle-base station, and the fractional tube occurs because the stone was set before the line was measured.

There are five other marking-stones, all of them 3 feet long, set with their tops 1 foot below the surface of the ground. They are placed at the west ends of the following tubes, (counting from east to west,) viz: 84th, 184th, 299th, 1029th, 1389th. Besides these, there are six stones set for surface-marks. Their positions are given in the notes.

There were 12 days of comparisons: 6 before measurement, 2 at the middle of measurement, and 4 after measurement.

The east part of the base was measured in 9 days, the west part in 10, and the first 299 tubes were remeasured in 4 days, making 23 days in all.

The average number of tubes measured per day was 77. Observations were made on 2 days for backward motion of tubes due to pressure of contact. The party returned to this office October 26.

My thanks are due Assistant Engineers Pratt, Olds, and Russel for the skill and care with which they performed all the work assigned them.

During the winter I have been engaged in determining the constants of the two comparators, comparing the lake-survey standards, and reducing the Sandy Creek and Buffalo bases.

Very respectfully, your obedient servant,

E. S. WHEELER,
Assistant Engineer.

General C. B. COMSTOCK.

5.—REPORT OF MR. G. Y. WISNER, ASSISTANT ENGINEER.

WESTFIELD, N. Y., *June* 18, 1876.

GENERAL: I have the honor to submit the following report of operations of the party under my direction during the year commencing May 1, 1875.

With Otis Dockstader as recorder and T. Hockridge as attendant, I left Detroit, May 3, to reconnoiter for secondary stations between Oswego, N. Y., and the mouth of Niagara River, for the purpose of connecting the shore-work of Lake Ontario with main triangulation. This work was completed on May 24, and the party at once commenced the work of reading angles of the main triangulation at Oswego. Owing,

however, to the dense smoke on the lake and to the length of lines to be seen over, the party was detained till into July before the necessary measurements were obtained.

After leaving Oswego the party occupied the main stations at Victory, Rochester, Pekin, Tonawanda, West Base, East Base, Middle Base, Buffalo Plains, and Azimuth Station at Tonawanda. The party also made the secondary measurements for shore-connections at Oswego, Victory, Fair Haven, Rochester, Pekin, Brock's Monument, and Tonawanda.

On October 15 the party returned to Detroit. The season was unusually bad for work on account of the smoke and heavy winds that continued throughout.

After returning to the office I was occupied until February 1 with the reductions of the season's field-notes and tabulating results in the office-record. From February 1, till leaving for field-duties in May, I was engaged in making the duplicate computation of Assistant A. R. Flint's longitude work at Tonawanda and Mannsville, N. Y.

The following is a summary of the season's field-work:

Number of stations located	11
Number of main stations occupied	9
Number of azimuth-stations occupied	1
Number of main angles read	45
Number of secondary angles read	61
Number of zenith distances read	120
Number of stars observed for azimuth	20
Number of stars observed for time	30

The following table gives the results of observations for azimuth at Tonawanda, N. Y. Each result is the mean of sixteen readings between star and reference light.

T. & S.—14-inch theodolite, G. Y. Wisner, observer.

Date.	Polaris.	δ Urs. Min.	51 Cephei.	λ Urs. Min.	Mean for night.
1875.	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
August 24	235 17 52.75	235 17 52.00	235 17 51.07	235 17 51.72	235 17 51.885
August 25	52.42	51.79	52.20	48.68	51.273
August 26	52.75	52.07	51.85	49.76	51.607
August 27	50.10	52.63	52.34	51.42	51.623
August 28	51.89	51.83	53.14	51.35	52.052

Azimuth of reference light from observation post	= 235° 17′ 51″.688
Corrected to station Tonawanda	= 01″.665
Azimuth of light from station Tonawanda	= 235° 17′ 50″.023
Angle light, Tonawanda, Buffalo Plains	= 79° 04′ 50″.403
Azimuth of Buffalo Plains from Tonawanda	= 314° 22′ 40″.426

Very respectfully submitted.

GEORGE Y. WISNER,
Assistant Engineer.

General C. B. COMSTOCK,
In charge of Survey Northern and Northwestern Lakes.

6.—REPORT OF MR. A. R. FLINT, ASSISTANT ENGINEER.

OFFICE UNITED STATES LAKE SURVEY,
Detroit, Mich., June 15, 1876.

GENERAL: I have the honor to submit the following report on field and office work, from May 1, 1875, to April 30, 1876.

From May 1 until August 23 I was engaged on reconnaissance for primary triangulation in Michigan, Indiana, and Illinois.

During the month of May points were selected for erecting stations from near Michigan City, Ind., to Bronson, Mich., a distance of about 80 miles.

From the 1st of June until the 20th of August the reconnaissance extended from Chicago to the Ohio River, near the mouth of the Wabash River.

I also located approximately a primary base-line near Chicago, 4½ miles in length.

During the time occupied fifty-six points were located for primary stations, the distance along a central line of the system of triangles being about 350 miles.

On returning to Detroit, I received orders to observe, in connection with Lieut. D. W. Lockwood, Corps of Engineers, for personal equation at Detroit, and for difference of longitude between Detroit and the trigonometrical station at Tonawanda, N. Y., and the one at Mannsville, N. Y.

Latitude-observations were made at Tonawanda with a zenith-telescope on four nights, observing each night about 30 pairs of stars.

Work was commenced at Detroit on August 30 for personal equation, before going to the field.

It was again determined after the work had been completed at Tonawanda and Mannsville, closing on December 27.

Lieutenant Lockwood observed at Detroit during the whole of the work.

Very unfavorable weather was experienced at all points, prolonging the work to a very much later time than was anticipated.

During the winter-months I was engaged in reducing the season's observations made by myself.

All the observations for time, both for personal equation and longitude, were reduced by the method of least squares. They were all computed in duplicate, mostly by Assistant Engineer Wisner.

On three occasions I have been absent from the office during the winter, inspecting stations erected in Michigan and Indiana.

Special reports have been heretofore submitted on all the work performed during the year.

I was very efficiently aided in the field-work by Mr. C. A. Marshall, to whose ability and accuracy in recording the success of the work was largely due.

Respectfully submitted.

A. R. FLINT,
Assistant Engineer.

Gen. C. B. COMSTOCK,
Major of Engineers.

7.—REPORT OF MR. G. A. MARR, ASSISTANT ENGINEER.

PORT COLBORNE, *Ontario, June* 10, 1876.

GENERAL: I have the honor to submit the following report on field and office work from April 16, 1875, the date of my last annual report, until leaving for field-work, May 17, 1876.

In accordance with your instructions of April 16, 1875, I proceeded to Buffalo, N. Y., April 20, and commenced the reconnaissance for primary triangulation, and also for a primary base-line near Buffalo, N. Y.

The ground in the vicinity of Buffalo was carefully examined, and the place for a base-line selected April 22, being located between Buffalo Plains and Tonawanda, N. Y.

Was joined by my recorder, Mr. Geo. C. Comstock, on April 22.

The reconnaissance for primary triangulation was commenced April 23.

Found that a system of triangulation from the base selected was practicable, and was joined by Assistant Engineer E. S. Wheeler May 3.

The place selected for a base-line was then carefully examined, 26,000 feet being chained and a line of levels run over 23,000 feet of the same.

The reconnaissance for primary triangulation was then continued west from Buffalo, and the following points selected, viz:

In New York State, at the east end and the west end of the base-line, Buffalo Plains, City Hall, in Buffalo, Hamburg, Sturgeon Point, Silver Creek, and Westfield.

In the Province of Ontario, at Drummondville, Ridgeway, Sugar Loaf Hill, Font Hill, Grand River, Long Point, and Houghton.

In Pennsylvania, at Erie and Edinboro.

In Ohio, at Conneaut, Andover, Orwell, Thompson, Claridon, Little Mountain Chester, Willoughby, Warrensville, Royalton, and Rockport.

This plan for the primary triangulation carries the work across Lake Erie as far west as the line from Houghton, Ontario, to Conneaut, Ohio.

The station at Victory, N. Y., was found to be too low to see the point selected at Clyde, N. Y., and two days were occupied in the investigation of this line, when it was decided to increase the height of Victory Station 12 feet.

I have also inspected and reported upon the following primary stations built by Mr Luke Crossley, viz: Tonawanda, Pekin, Gasport, Falkirk, Batavia, Morgansville, East Base, Buffalo Plains, Drummondville, Ridgeway, Sugar Loaf, Font Hill, Grand River, Long Point, Houghton, Sturgeon Point, Silver Creek, Westfield, Erie, and Edinboro.

The following points were selected as secondary stations, to be located from the primary stations and connected directly with the shore-work, viz:

Brock's Monument, near Queenston, Ontario; a point in Dalhousie, Ontario; the Light House and two other points in Port Colborne, Ontario; one point at Windmill Point, Ontario; triangulation-station 5 of Assistant Engineer Lamson, near Irving, N. Y.; triangulation-station 21½ of Assistant Engineer Mayer, and four other points at Dunkirk, N. Y.; triangulation-station 1 of Assistant Engineer Towar, near Brocton, N. Y.; triangulation-station Barcelona of Assistant Engineer Towar, near Westfield, N. Y., and two church-steeples in Westfield.

A point on shore near Ripley, N. Y., two points at North East, Pa., one point on shore near Harbor Creek, Pa., range-light and five other points in Erie, Pa., and vicinity; one point on shore near Miles' Grove, Pa., and one point on shore about two miles east of the State line between Pennsylvania and Ohio.

In order to obtain better intersections for secondary stations, an auxiliary station was located at Prospect, N. Y., being a small station built by myself at the time of locating it.

Completed the field-work and returned to Detroit November 9.

After making final reports of field-work was assigned to duty with Assistant Engineer E. S. Wheeler in reducing comparisons of Clarke yards A and B and Lake-Survey yards Nos. 6, 7, 8, 9, and 10, with each other.

A report on thermometer-corrections by Assistant Engineer T. Russell, being office report No. 536, was carefully examined from the original notes, any corrections found necessary being made directly in the report with red ink.

A complete reduction from the original notes of comparisons was made by the method of least squares, to determine the relative lengths and expansions of the Lake-Survey yards Nos. 6, 7, 8, 9, and 10.

Was engaged one week in making comparisons between the 15-foot standard bars, (brass and iron,) both packed in ice.

Was also occupied at various times in checking other computations, all of which will be reported upon by Assistant Engineer E. S. Wheeler.

A report being received at the office that, during a severe gale on April 10 and 11, station Long Point had been blown over, I was instructed to proceed to Long Point, Ontario, and investigate the matter.

Left Detroit May 6, and on arriving there found the station down and the timbers badly broken.

The high winds on such an exposed point had drifted the sand from under one side of the station, causing it to settle over very much, when its destruction was completed during the gale above mentioned.

Another point was selected with good ground for anchorage, but as this location was much lower, an extra height of 10 feet had to be added to the new station to be built there.

Returned to the office May 12, and commenced fitting out for the field-work of 1876.

During the past season had Mr. Geo. C. Comstock for recorder, who has my thanks for his valuable assistance, and I heartily recommend him for further employment.

Very respectfully, your obedient servant,

G. A. MARR,
Assistant Engineer.

Gen. C. B. COMSTOCK,
Major of Engineers.

8.—REPORT OF MR. R. S. WOODWARD, ASSISTANT ENGINEER.

STURGEON POINT, N. Y., *June* 10, 1876.

SIR: In compliance with your instructions, I have the honor to submit the following report concerning field-work done by my party during the summer of 1875 and work done by me in the office during the winter of 1875–'76.

In accordance with your orders, my field-party was organized May 1, 1875, with Mr. E. B. Wilson as recorder and Mr. S. L. Large as observer's attendant.

We were assigned to duty on the primary triangulation of Lake Ontario, and left Detroit for Sandy Creek, N. Y., on May 4.

Arriving at Sandy Creek May 5, we proceeded to South Base for the purpose of reading the angles at that station between North Base and Mannsville and Mannsville and Sandy Creek stations. Before these angles could be read, however, it was found necessary to raise South Base station 12 feet and cut away considerable timber on line to Mannsville.

On May 21, the work being completed at South Base, our party moved to Mannsville for the purpose of reading the angles at that station between Sandy Creek and South Base and South Base and North Base.

This work was completed May 27.

May 28 our party moved to Sodus station, near Sodus, N. Y.

Owing to very unfavorable weather, we were unable to complete the work at this station till the 9th of July.

Leaving Sodus July 10, we occupied in succession stations Walworth, Brockport, and Gasport, in New York, and Font Hill, in Ontario.

The work at Font Hill was completed on September 15, and we were then ordered to return to New York and re-read some of the angles of the triangles east of Rochester.

Between September 15 and October 13, stations Turk Hill, Scottsville, and Pinnacle Hill were occupied and the work assigned to us completed.

On October 14 we left the field and returned to Detroit.

In addition to the work on the primary triangulation, considerable secondary work in the way of shore-line connections, &c., was done.

Land-survey corners were located at Mannsville, Brockport, and Gasport, and churches were located in Sodus and Brockport.

Considerable time was spent also in an examination of the 12-inch Troughton and Simms theodolite used in reading primary angles.

The results of this examination have already been reported.

In conclusion, I desire to express my indebtedness to Messrs. Wilson and Large for their uniformly valuable assistance; much credit is due them for the promptness and efficiency with which they discharged their duties.

Below is shown a summarized statement of the amount of field-work done between May 4 and October 14, 1875:

Number of primary stations occupied	10
Number of secondary stations occupied	13
Number of primary angles measured	33
Number of secondary angles measured	51
Number of vertical angles measured	13
Number of bases chained	6

The following is a summary of work done by me in the office between October 14, 1875, and May 1, 1876:

1. Tabulation of results of field-work of summer of 1875.
2. Reduction of comparisons made between brass standard bar and base-line tubes I and II, for the purpose of obtaining the expansions of the tubes.
3. Determination of a formula representing the effect of the periodic errors of graduation of the horizontal circle of the 12-inch Troughton and Simms theodolite.
4. Duplicate computation of the expansions and lengths of the Clarke yards A and B.
5. Computations of corrections to the lengths of Minnesota Point, Keweenaw, and Fond du Lac bases.

In addition to the above, there were made various miscellaneous computations of minor importance.

Very respectfully,

R. S. WOODWARD,
Assistant Engineer.

Gen. C. B. COMSTOCK,
Superintendent United States Lake Survey.

9.—REPORT OF MR. T. RUSSELL, ASSISTANT ENGINEER.

DETROIT, MICH., *June* 15, 1876.

GENERAL: The following is a report of the work done by me between May 1, 1875, and May 1, 1876.

I left Detroit with my recorder, Mr. G. W. Carman, May 4, for triangulation-station Amherst Island, to finish the horizontal angles which had not been completed the previous year. After leaving Amherst Island triangulation-station Vanderlip was occupied. The measurement of angles at this station was attended with some difficulty, as the flashes at triangulation-station Sodus, 50 miles distant, and triangulation-station Oswego, 44 miles distant, were visible only when there was extraordinary refraction. Work at this station was delayed during June by smoky atmosphere. The flash at triangulation-station Oswego was less frequently visible than that at triangulation-station Sodas, and was never even moderately steady.

Measurements were made whenever the lights were visible, and the results of the angles between triangulation-station Sodus—triangulation-station Oswego and triangulation-station Oswego—triangulation-station Duck Island show greater ranges than is customary in good work with repeating theodolite Gambey No. 1. On the night of June 13 the light at Oswego light-house was visible and perfectly steady; an angle was measured between it and False Ducks light-house. The required number of results on all the angles at triangulation-station Vanderlip and a sketch of the shore-line in the vicinity was completed July 12.

Triangulation-station Morganville, triangulation-station Falkirk, and triangulation-station Tonawanda were occupied in succession. In accordance with instructions from Assistant Engineer G. Y. Wisner I left triangulation-station Tonawanda August 31, without finishing the angles at that station, and proceeded to Grenadier Island, Lake Ontario, to remeasure an angle between triangulation-station Duck Island—triangulation-station Stony Point, and also an angle at triangulation-station Stony Point between triangulation-station Duck Island and, triangulation-station Grenadier. Owing to stormy weather on Lake Ontario during the month of September, and having only an open sail-boat in which to reach Duck Island, the work of remeasuring those two angles was not completed until September 28.

Triangulation-station Tonawanda was re-occupied October 1, to complete the angle between triangulation-station Falkirk—triangulation-station Ridgeway, which had been left unfinished.

October 5 triangulation-station Hamburg was occupied, and the work there completed October 22.

October 23 myself and recorder arrived at Detroit.

During the season in the field, from May 4 to October 23, 8 primary stations were occupied and 29 primary angles measured. Angles between primary stations and various light-houses and churches were also measured.

From October 23 to May 1 I was engaged in office-work; the angles observed during the season were reduced and tabulated, and various miscellaneous computations were made. The reduced angles at all the stations occupied close the horizons under 360°, showing that Gambey No. 1 measures an angle constantly about $0''.5$ too small.

December, 1875, the freezing-points of thermometers A_1, A_2, A_3, A_4, B_1, B_2, B_3, B_4, of new standard Troughton & Simms yards were determined; also of five Casella thermometers, 21472, 21473, 21474, 21475, 21476, and standard Troughton & Simms No. 230.

January, 1876, comparisons were made between the above thermometers at about 60° F. by allowing them to remain in water about half an hour before reading them.

Very respectfully,

T. RUSSELL,
Assistant Engineer.

Gen. C. B. COMSTOCK,
Superintendent United States Lake Survey.

10.—REPORT OF MR. J. H. DARLING, ASSISTANT ENGINEER.

DETROIT, MICH., *June* 13, 1876.

GENERAL: I have the honor to submit the following report of field and office work done by me during the period of one year prior to May 1, 1876.

FIELD-WORK.

From May 6, 1875, to November 11, I was engaged in reading angles on the main triangulation of Lakes Ontario and Erie, my instrument being the Repsold theodolite No. 1, with a 10-inch limb. Mr. L. D. Wines served as recorder.

Primary stations occupied	6
Primary angles read	26
Secondary angles read	8
Tertiary angles read	13
Vertical angles (zenith-distances) read to primary stations	23
Light-houses read to	10
Churches and other prominent public buildings read to	18

OFFICE-WORK.

During the winter I corrected and tabulated my summer's work, reduced Assistant Wisner's azimuth-observations made at Tonawanda, N. Y., Lieutenant Bailey's observations for value of the micrometer of Pistor and Martin's transit No. 2, Lieutenant Ruffner's observations for the latitude of Buffalo, and made other computations of less extent.

Very respectfully, your obedient servant,

J. H. DARLING,
Assistant Engineer.

Gen. C. B. COMSTOCK,
Superintendent United States Lake Survey.

J. H. Darling, in 1875, with Repsold No. 1.

Station and angle.	Number of single results.	Range.	Probable error. Single results.	Probable error. Final results.
		"	"	"
Stony Point:				
Sandy Creek, North Base	24	6.70	1.08	0.22
South Base, Sandy Creek	30	7.20	1.19	.22
North Base, South Base	42	9.10	1.45	.22
Ducks:				
Oswego, Vanderlip	40	10.40	1.77	.28
Vanderlip, Amherst	40	8.40	1.25	.20
Scottsville:				
Pinnacle Hill, Turk's Hill	26	7.05	1.18	.23
Turk's Hill, Morganville	36	10.90	1.63	.27
Morganville, Brockport	34	7.10	1.17	.20
Brockport, Pinnacle Hill	34	9.25	1.37	.23
Batavia:				
Albion, Morganville	26	9.20	1.20	.24
Morganville, Falkirk	24	4.40	0.90	.18
Falkirk, Gasport	30	6.60	1.04	.19
Gasport, Albion	28	8.05	1.16	.22
Ridgeway:				
Sugar Loaf, Font Hill	24	5.70	0.99	.20
Font Hill, Drummondville	24	5.65	1.17	.24
Drummondville, Tonawanda	22	4.35	0.82	.17
Tonawanda, West Base	24	6.10	1.00	.20
West Base, Buffalo	24	5.70	1.11	.23
Buffalo, Hamburg	40	7.60	1.41	.22
Hamburg, Sturgeon Point	24	7.45	1.23	.25
Sturgeon Point, Silver Creek	26	4.95	0.93	.18
Silver Creek, Sugar Loaf	26	4.75	0.94	.18
Buffalo:				
Sturgeon Point, Ridgeway	24	6.80	1.26	.26
Ridgeway, Hamburg	24	7.40	1.21	.25
Hamburg, Sturgeon Point	24	5.85	1.11	.23
Hamburg, Ridgeway	24	5.25	.94	.19
Mean			=1.17	

If m=total number of single results.
n=total number of angles.
$[vv]$=sum of squares of all the residuals.
Then

$$r=.6745\sqrt{\frac{[v\,v]}{m-n}}=.6745\sqrt{\frac{2561}{718}}=1.''27,$$

which is the probable error of a single result as deduced from the whole season's work.

11.—REPORT OF MR. A. C. LAMSON, ASSISTANT ENGINEER.

DETROIT, MICH., *June* 7, 1876.

MAJOR: I have the honor to make the following report of work accomplished under my charge during the year ending May 1, 1876:

I left Detroit May 4, 1875, in charge of a United States lake-survey shore party, and was landed at Braddock's Point, N. Y., May 13, where I went into camp with a party consisting of 3 assistants and 21 men.

My shore-line work extended about 2 miles to the eastward and 6 miles to the westward of camp.

A survey was also made of the hydrography and topography adjoining.

May 29 I moved camp to Sandy Creek, N. Y.; my work embracing the shore-line 6 miles to the eastward and 8 miles to the westward of camp, including the adjoining hydrography and topography.

June 14 I moved camp to Olcott, N. Y.; my shore-line work extending eastward 8 miles and westward 6 miles, including the hydrography and topography adjoining.

July 6 I moved camp to La Salle, N. Y., on the Niagara River; my work extending from 4 miles above Niagara Falls to Tonawanda on the main shore, and from Navy Island to opposite Tonawanda, on Grand Island.

A hydrographical survey was made of the river, and the topography was carried inland about ¾ of a mile on the main shore, and also on Grand Island.

July 31 I moved camp to the west side of Grand Island; my work extending from a point in Canada opposite Navy Island to Black Creek, Canada, and from Navy Island to a point opposite Black Creek, on Grand Island.

A survey was also made of the hydrography and topography included in this field.

August 14 I moved camp to Irving, N. Y.; my work embracing the shore-line 12 miles to the north of camp, and 6 miles to the south of same, with the hydrography and topography included in this field.

September 2 I moved camp to Erie, Pa., where a survey was made of Erie and Erie Harbor; also of the shore 8 miles to the eastward of Erie, and 6 miles to the westward of same, including the hydrography and topography adjoining.

On October 10 my party was recalled from the field, and after discharging crew, and storing camp-equipage at Erie, Pa., I reported at Detroit October 13.

During the winter-season the shore-line topography, and hydrography were plotted on 14 antiquarian sheets.

The following table shows the amount of field-work accomplished:

Table of field-work accomplished.

Stations built	168
Sounding-stakes set	991
Theodolite pointings	17,289
Theodolite readings	22,245
Lines of soundings	987
Casts of the lead	33,656
Square miles hydrography	89
Square miles topography	73
Buoys set	120
Observations for azimuth	15
Compass readings	335
Sextant angles measured	26
Miles of shore-line	160

Very respectfully, your obedient servant,

A. C. LAMSON,
Assistant Engineer.

Maj. C. B. COMSTOCK,
Corps of Engineers, U. S. A.

12.—REPORT OF MR. F. M. TOWAR, ASSISTANT ENGINEER.

OFFICE UNITED STATES LAKE SURVEY,
Detroit, Mich., June 9, 1876.

MAJOR: I have to submit the following report of work done by the party under my charge since the 1st of May, 1875:

On May 4 my party left Detroit on board of the United States steamer Ada for Lake Ontario.

The first camp was established at the mouth of the Genesee River, New York.

The work at this camp extended 5 miles to the east of Genesee River, along the lake-shore, and a like distance to the westward.

The hydrography was carried out into the lake to an average distance of a mile, and the topography extended inland from the lake-shore $\frac{3}{4}$ of a mile.

In addition to the work done on the shore of the lake, a survey was made of Irondequoit Bay, and of the Genesee River from its mouth to the lower falls.

On June 21, 1875, my party was transferred to Youngstown, at the mouth of Niagara River.

From this place I worked along the shore of the lake to the eastward 4 miles, and to the westward 6 miles, and extended the work up Niagara River a distance of 6 miles, including the villages of Lewiston and Queenstown.

At the mouth of the Niagara River I was obliged to carry the hydrography out from shore a distance of $3\frac{1}{2}$ miles, in order to include the dangerous shoals in that locality.

On July 19 I moved the party to Suspension Bridge.

From this camp I worked from the point reached from the camp at Youngstown to the foot of Navy Island, about 3 miles above Niagara Falls.

On August 23 the above work was completed, and I proceeded with the party to Westfield, N. Y., about 60 miles southwest from Buffalo, on Lake Erie.

While at the camp at Westfield I extended my work along the shore 10 miles to the eastward, and 7 miles to the westward, including the required amount of topography and hydrography.

On September 21 my party was transferred to Fairview, Pa.

A survey of 10 miles of the lake-shore was completed from this place, when my party was disbanded for the season and returned to Detroit.

On October 11 I was ordered to proceed to Niagara Falls and determine as accurately as possible the present position of the crest of the falls with reference to certain permanent points established in that vicinity.

I completed this work on October 16, and returned to Detroit.

I am indebted to Messrs. Donovan, Winchell, and Lightner for valuable assistance in the field, and to the former for faithful attention to duty and accurate work done in the office.

The following table gives the amount of my field-work in detail:

Miles of shore-line	133
Square miles of topography	85
Square miles of hydrography	56
Casts of the lead	19,000
Theodolite pointings	38,084
Theodolite readings	53,973
Altitudes determined	9,906
Observations for meridian	10
Buoys located	75
Triangulation posts built	126
Sounding-stations built	1,039
Lines of sounding	886
Base-lines chained	8
Triangles computed	78
Magnetic readings	78

Since returning from the field the above work has been plotted on 12 sheets of antiquarian paper, and 600 pages of computations made.

Very respectfully, your obedient servant,

F. M. TOWAR,
Assistant Engineer.

Maj. C. B. COMSTOCK,
Corps of Engineers, U. S. A.

13.—REPORT OF MR. J. R. MAYER, ASSISTANT ENGINEER.

DETROIT, MICH., *June* 8, 1876.

SIR: Agreeably to your circular of the 6th instant, I have the honor to submit the following report of the work done by the party under my charge during the season of 1875, together with the amount of office-work accomplished during the winter, up to May, 1876.

In pursuance of your orders I began the season's work at a point 4 miles east of Pultneyville, N. Y., the United States steamer Ada having landed the stores and camp-equipage belonging to my party at Pultneyville on May 9; and after completing the survey of the part of shore allotted to me there, my camp was moved on June 12 by the steamer Ada to County Line, N. Y., near Golden Hill Creek; and on July 14, the work of shore-line, topography, and inshore hydrography being finished on this section, the steamer Ada moved my party, on July 15, to Niagara, Canada, from which place I was ordered to go to West Hamburgh, N. Y.; from whence, on August 19, I was moved to Dunkirk, N. Y.; and on September 22, the survey of the sections of West Hamburgh and Dunkirk being completed, my party went on board the steamer Ada, and was landed on the same day on the eastern extremity of Long Point, Canada; the survey of which place was finished on October 11, and the party transported by the steamer Ada to Erie, Pa., where the property of the United States Lake Survey was stored away and the men paid and discharged.

The lines of soundings run during the season were determined by the method of "ranges." I used mostly for this purpose the "reflecting ranger," to which instrument I have lately made some improvements, concerning which I have already submitted to you a report, which I may be allowed here briefly to recapitulate, as follows:

1st. In adapting to it a small telescope.

2d. In making the side mirror movable, as the axis of the telescope may not form exactly an angle of 45° with the plane of the horizon-glass or front mirror, the error is corrected by moving the side mirror so as to make the image of the rear object coincide with the front object pointed at, which gives for value of the angle between the two mirrors $\pm$ 90°.

3d. Under the side mirror is fixed a screw which moves in an opening, and to this screw is attached an index, which slides on a divided brass arc fixed under the bottom of the instrument.

When the side or movable mirror is adjusted, the screw is fastened, and the index corresponding to a division on the brass arc is recorded, in order to ascertain the correct position of the side mirror without any other adjustment of it.

The adjustment of the instrument is checked by reversing the operation, by pointing to the rear object to see if the image of the front object coincides with it.

Two points as a long range for adjustment of this instrument can be determined at once by using the telescope of a small theodolite, well adjusted for collimation.

During the winter of 1875 and 1876 I made the computations of the co-ordinates of the azimuth stations or stakes, and I also reduced and transferred in pencil the field-plots on ten sheets of antiquarian paper, and made the drawing of one sheet, Assistant Engineer J. A. Ockerson drawing the work which I had put in pencil on 9 sheets.

To Assistant Engineer J. A. Ockerson and Recorder A. Beebe I wish to express my thanks for their valuable assistance and carefulness during the field operations. I wish also to mention that Recorder O. C. Simonds rendered good services in as much as he was able.

I am indebted to Assistant Engineer G. E. Fell, of Col. C. E. Blunt's United States Engineer Office, for the determination of the data of the water-standard level or zero of gauge, in reference to a stone monument as "bench-mark" at Dunkirk Harbor, New York.

The following table shows in detail the amount of field-work:

	From May 12 to June 30.	From July 1 to Oct. 11.	Total amount.
Azimuth-stations built	16	20	36
Sounding-stations built	85	164	249
Stakes located for azimuth-lines	45	74	119
Buoys located	31	154	185
Lines sounded	95	345	440
Miles of soundings	63	288. 2	351. 2
Casts of the lead	1, 735	9, 330	11, 065
Pointings of theodolite	351	648	999
Readings of theodolite	702	1, 278	1, 980
Topography.. Horizontal angles	3, 966	6, 568	10, 534
Topography.. Vertical angles	1, 575	1, 753	3, 328
Miles of azimuth-lines run with the chain	29. 6	35. 75	65. 35
Miles of stadia-lines	52. 5	96. 10	148. 60
Miles of shore-line	24. 2	48. 60	72. 80
Square miles of topography	16	27. 85	43. 85
Square miles of hydrography	7. 50	48. 74	56. 24
Observations for azimuth	3	7	10

Very respectfully, your obedient servant,

J. R. MAYER,
Assistant Engineer.

Maj. C. B. COMSTOCK,
Corps of Engineers, Superintendent United States Lake Survey.

14.—REPORT OF MR. FREDERICK TERRY, ASSISTANT ENGINEER.

OFFICE UNITED STATES LAKE SURVEY,
Detroit, Mich., June 9, 1876.

MAJOR: In obedience to your instructions, I have the honor to submit the following report of the operations of the party under my charge during the year ending May 1, 1876.

I went into camp May 11, 1875, about 5 miles east of Charlotte, N. Y., and remained there until June 9, making a survey of that portion of the shore lying between Smoky Point and Irondequoit Bay.

I was then moved by the steamer Ada to Oak Orchard Harbor, N. Y., where I made a survey of the shore from 7 miles east to 7 miles west of that place.

On July 12, I was conveyed by the steamer Ada to Niagara, Ontario, on my way to Buffalo.

I arrived at Buffalo on July 14, and remained there till October 1, making a survey of the Niagara River from Lake Erie to 3 miles below the head of Grand Island; this included a survey of Buffalo.

On the completion of this work I was moved by the steamer Ada to Elk Creek, Lake Erie, where I made a survey of 2½ miles of shore.

On October 10 I broke up camp and proceeded to Erie, where my camp-equipage was stored and my party discharged.

I arrived in Detroit October 12, where I have been employed ever since in reducing my work

To Assistant Engineer Morrow, who was with me until August 20, I wish to return thanks for his faithful and very valuable services.

I give below in tabular form the work performed by my party:

Stations built	101
Sounding-stakes	810
Theodolite-pointings	20,111
Theodolite-readings	27,616
Casts of lead	28,567
Buoys set	97
Compass-readings	108
Observations for azimuth	8
Shore-line, (miles)	89
Square miles hydrography	42½
Square miles topography	56½

Very respectfully, your obedient servant,

FREDERICK TERRY,
Assistant Engineer.

Maj. C. B. COMSTOCK,
Corps of Engineers, U. S. A.

15.—REPORT OF MR. JOHN EISENMANN, ASSISTANT ENGINEER.

OFFICE UNITED STATES LAKE SURVEY,
Detroit, Mich., March 9, 1876.

SIR: I have the honor to submit the following report of the work done by the shore party under my charge from May 4, 1875, to March 9, 1876.

I left Detroit on the steamer Ada on May 4, and on the morning of the 7th the portion of my camp-equipage stored in the fall of 1874 was taken on board at Oswego, N. Y.

I arrived at Great Sodus Bay on the same day, and found that my party had been fully organized by Assistant Engineer Jared Teeple.

Owing to storms, I was unable to make a landing until the morning of the 9th.

The non-arrival of my camp-equipage shipped by vessel prevented my going into camp, and I quartered my party at the Johnson house, at Sodus Point, until the 14th, when all went into camp on Charles Point. The work, however, was not delayed.

The work at this camp, which was completed on June 16, extended from East Bay, the western terminus of last season's operations, to about 7 miles west of Sodus Point and included Great Sodus Bay and the village of Sodus Point.

On the 17th camp was moved by the steamer Ada to 5 miles west of Wilson Harbor, N. Y.

The work at this camp extended from the piers of Wilson Harbor westward a distance of 8 miles, and it was completed on June 28.

On the 29th, camp was moved by the steamer Ada to Port Dalhousie, Ontario.

The work at this camp, which was completed on July 20, extended 5 miles east and west of Port Dalhousie, and included the basin of the Welland Canal above the first lock, and the village of Port Dalhousie, Ontario.

On the 21st of July camp was moved, via the Welland Railway, to Port Colborne, Ontario, on Lake Erie.

The work at this camp extended from Morgan's Point on the west to Point Abino, 9 miles to the east of Port Colborne, and included the village of Port Colborne and a mile of the Welland Canal.

Recorder R. B. Hostetler reported for duty on July 27.

The work having been completed, I was moved by the steamer Ada, on the 16th of August, to Ridgeway, Ontario.

The work in this vicinity extended from Point Abino on the west to within 4 miles of Buffalo, N. Y., on the east, a distance of 8 miles, and included the village of Ridgeway.

The work was completed on August 31. On September 1, camp was moved by the steamer Ada to the mouth of Sixteen Mile Creek, near North East, Pa.

The work in this vicinity extended 7 miles each side of camp, and was very much delayed by heavy storms.

On October 5, my party was moved from this camp by the steamer Surveyor to the mouth of Crooked Creek, near North Springfield, Pa.

Only 3 miles of work was done at this camp.

I broke camp for the season of 1875 on October 12, and my camp-equipage was stored and party disbanded at Erie, Pa., on the same day.

I reported for duty at Detroit on October 14.

All my work during the season is based on systems of tertiary triangulation, with check bases, and connections with either primary or secondary triangulation were made at each camp.

I was faithfully assisted in the field by Assistant Engineer Jared Teeple and Recorders A. N. Darrow, R. B. Hostetler, and E. G. Aikman, and in the office, for the whole winter season, by Assistant Engineer Jared Teeple; since December 27, by Draughtsman M. H. Church, and since February 19, by Assistant Engineer F. G. Buckley.

The following table gives the work in detail.

Theodolite-pointings	25,444
Theodolite-readings	31,923
Vertical angles	7,385
Tertiary triangulation-stations built and occupied	150
Primary and secondary stations connected with	13
Churches and light-houses located	15
Sounding-stakes built	973
Buoys set	211
Lines sounded	844
Casts of lead	39,350
Azimuth observations	13
Magnetic declination observations	29
Base-lines measured	13
Shore-lines, miles of	121
Topography, square miles	60
Hydrography, square miles	75½

During the winter season the shore-line, topography, and hydrography were plotted on 13 antiquarian sheets, and 246 triangles and 30 meandered stadia-connections, each exceeding 1 mile in length, were computed and co-ordinated.

Very respectfully, your obedient servant,

JOHN EISENMANN,
Assistant Engineer.

Maj. C. B. COMSTOCK,
Bvt. Brig. Gen. U. S. A., Supt. U. S. Lake Survey.

16.—REPORT OF MR. A. T. MORROW, ASSISTANT ENGINEER.

OFFICE UNITED STATES LAKE SURVEY,
Detroit, Mich., June 7, 1876.

MAJOR: I have the honor to make the following report of the work done at Sand Beach by the party under my charge.

In obedience to your orders, I left Detroit on August 25, 1875, with a party of 8 men, and proceeded to Sand Beach, Lake Huron.

On the 27th of August, I began a survey of the "harbor of refuge" and vicinity, and completed the same on October 9, when I returned to Detroit and discharged my party.

After my return to the office I made a plot of the work on a scale of $\frac{1}{8000}$.

The following is a summary of the field-work.

Miles of developed shore-line	4
Square miles of topography	3
Square miles of hydrography	5
Theodolite-pointings	1,742
Vernier-readings	2,638
Lines of soundings	221
Casts of the lead	7,940
Triangulation-stations built	10
Sounding-stations built	93
Buoys located	62
Compass-readings	68
Observations for azimuth	2
Base-line measurements	3

Very respectfully, your obedient servant,

A. T. MORROW,
Assistant Engineer.

Maj. C. B. COMSTOCK,
Corps of Engineers, U. S. A.

APPENDIX N.—CHARTS.

1.—LIST OF PUBLISHED LAKE-SURVEY CHARTS.

No.	Name of chart.	Scale.	Year of publication.
1	Lake Erie	1 : 400, 000	1852
2	West End Lake Erie	1 : 120, 000	1852
3	Kelly's and Bass Islands, Lake Erie	1 : 50, 000	1852
4	Straits of Mackinac	1 : 120, 000	1856
5	East Neebish Rapids, Saint Mary's River	1 : 15, 000	1854
6	Saginaw River	1 : 10, 000	1867
7	Saint Clair Flats	1 : 32, 000	1857
8	Buffalo Harbor	1 : 30, 000	1857
9	Tawas Harbor, Lake Huron	1 : 16, 000	1857
10	Beaver Island Group, Lake Michigan	1 : 120, 000	1855
11	Eagle Harbor, Lake Superior	1 : 5, 000	1858
12	Agate Harbor, Lake Superior	1 : 10, 000	1858
13	River Saint Marie No. 1	1 : 40, 000	1858
14	River Saint Marie No. 2	1 : 40, 000	1858
15	Maumee Bay, Lake Erie	1 : 30, 000	1858
16	Eagle River, Lake Superior	1 : 10, 000	1859
17	Ontonagon Harbor, Lake Superior	1 : 16, 000	1859
18	Saginaw Bay, Lake Huron	1 : 120, 000	1860
19	Thunder Bay, Lake Huron	1 : 40, 000	1860
20	Marquette Harbor, Lake Superior	1 : 50, 000	1860
21	Presque Isle and Middle Island, Lake Huron	1 : 40, 000	1860
22	Lake Huron	1 : 400, 000	1860
23	South End Lake Huron	1 : 120, 000	1861
24	Grand Island, Lake Superior	1 : 25, 000	1862
25	West End of Lake Superior	1 : 32, 000	1863
26	Grand and Little Traverse Bays, Lake Michigan	1 : 120, 000	1863
27	North End of Green Bay	1 : 120, 000	1864
28	Copper Harbor, Lake Superior	1 : 10, 000	1866
29	L'Anse and Keweenaw Bay, Lake Superior	1 : 30, 000	1866
30	Portage Lake and River, Lake Superior	1 : 30, 000	1865
31	Lake Superior No. 1	1 : 400, 000	1872
32	Lake Superior No. 2	1 : 400, 000	1870
33	North End of Lake Michigan	1 : 400, 000	1867
34	Huron Islands	1 : 30, 000	1869
35	South End of Green Bay	1 : 120, 000	1864
36	Lake Superior No. 3	1 : 400, 000	1873
37	Saint Clair River	1 : 40, 000	1872
38	Isle Royale, Lake Superior	1 : 30, 000	1872
39	Mouth of Detroit River	1 : 20, 000	1874
40	City of Chicago	1 : 20, 000	1874
41	Lake Saint Clair	1 : 50, 000	1874
42	Saint Lawrence River No. 1	1 : 30, 000	1874
43	Sandusky Bay	1 : 20, 000	1874
44	Saint Lawrence River No. 2	1 : 30, 000	1875
45	Saint Lawrence River No. 3	1 : 30, 000	1875
46	Saint Lawrence River No. 4	1 : 30, 000	1876
47	Sand Beach Harbor of Refuge, Lake Huron	1 : 8, 000	1876
48	Niagara Falls	1 : 10, 000	1876

2.—TABLE SHOWING THE ANNUAL ISSUE OF CHARTS OF THE NORTHERN AND NORTH-WESTERN LAKES.

Prior to October 1, 1857	2, 500	July 1, 1866, to July 1, 1867	5, 464
October 1, 1857, to October 1, 1858	1, 675	July 1, 1867, to July 1, 1868	6, 354
October 1, 1858, to October 1, 1859	2, 600	July 1, 1868, to July 1, 1869	5, 634
October 1, 1859, to October 1, 1860	4, 890	July 1, 1869, to July 1, 1870	4, 597
October 1, 1860, to October 1, 1861	3, 254	July 1, 1870, to July 1, 1871	5, 328
October 1, 1861, to October 1, 1862	5, 245	July 1, 1871, to July 1, 1872	3, 649
October 1, 1862, to October 1, 1863	4, 084	July 1, 1872, to July 1, 1873	5, 546
October 1, 1863, to October 1, 1864	3, 283	July 1, 1873, to July 1, 1874	7, 701
October 1, 1864, to October 1, 1865	2, 589	July 1, 1874, to July 1, 1875	5, 039
October 1, 1865, to July 1, 1866	2, 082	July 1, 1875, to July 1, 1876	4, 101

3.—LIST OF TRACINGS FURNISHED TO PARTIES FROM JULY 1, 1875, TO JUNE 30, 1876.

Name.	Date.	Locality.
Maj. G. L. Gillespie, Corps of Engineers	Nov. 26, 1875	Lake Michigan shore-line and soundings from Chicago to South Chicago.
Lieut. Col. C. E. Blunt, Corps of Engineers	Apr. 13, 1876	Niagara River, vicinity of Tonawanda, N. Y.
H. E. Morse, Clayton, N. Y	Apr. 15, 1876	Saint Lawrence River, vicinity of Clayton, N. Y.

NOTES ON EUROPEAN SURVEYS.

COMPILED UNDER THE DIRECTION OF GENERAL C. B. COMSTOCK, MAJOR OF ENGINEERS, U. S. A.

PREFACE.

Numerous manuscripts, books, and maps relating to European surveys were sent to me by the Engineer Department in 1875 and 1876, for examination and report. They were carefully looked over, abstracts were made of such as were deemed most important, and these were, from time to time, forwarded to the Engineer Department for its use. Subsequently, it was deemed advisable to print them, that their information might become more generally available. It should be remembered that they are mainly memoranda for those familiar with such work, derived from data at hand. Considered as accounts of surveys in different countries, they necessarily have many imperfections.

C. B. C.

LAKE SURVEY OFFICE, *Detroit, October* 9, 1876.

CONTENTS.

CHAPTER I.

LAKE SURVEY OFFICE,
Detroit, Mich., April 25, 1876.

GENERAL: A large amount of material relating to European geodetic and topographical surveys has been sent to me in the last six months for examination. This material consists of pamphlets and manuscripts relating to organizations and methods used, and of maps showing the results of the surveys.

From the descriptions of organizations and methods I have selected such as seemed of most interest to those concerned in such matters. I have had the maps examined as to their construction, execution, and contents.

Selections from the papers and notes upon the maps are annexed, giving a good deal of detail in reference to the surveys, and also photolithographs of some of the maps.

Perhaps some general remarks upon them may not be out of place

ORGANIZATIONS.

In GREAT BRITAIN the survey is called the ordnance survey, and is carried on by officers of the royal engineers, Lieutenant-General Sir Henry

James having been for many years at its head. December 31, 1874, there were employed on it 19 officers of royal engineers; 4 companies of royal engineers containing 121 non-commissioned officers, 243 sappers and 8 buglers, 1,000 civil assistants of different grades, and 448 laborers.

In PRUSSIA the trigonometrical, topographical, and chartographical work is intrusted to the staff corps of the army, while the geodetic work in connection with the "European measurement of degrees" is in charge of the Geodetic Institute, whose head is Lieut. Gen. J. J. Baeyer. In 1875, 43 staff officers were employed on the survey, together with a large number of gunners, civil assistants, and laborers.

In AUSTRIA, the survey of the Empire is intrusted to the Military Geographical Institute, an organization which has a general at its head and is under the war department. Its members are officers, military officials, civil assistants, non-commissioned officers, and workmen. In 1875 it employed 1,258 persons, of whom 283 were army officers varying in rank from lieutenant to major-general.

In ITALY, the surveys, prior to 1873, were carried on by officers of the staff corps under the chief of staff; but then the survey was given a more independent organization under the title of "Military Topographical Institute." Its present director is Major-General de Vecchi.

In SPAIN, the surveys are controlled by the Geographical Statistical Institute, with Major-General Ibañez at its head, and are largely carried on by officers of the army. In 1871 there were about thirty geodetic and topographical parties employed.

In SWITZERLAND, the surveys are under the direction of Colonel Siegfried, chief of staff of the army.

In SWEDEN, the geodetic and topographic survey is carried on by the officers of the general staff of the army. Its head is the chief of the topographical division, at present Colonel von Vegesack.

In RUSSIA, the military topographical corps is charged with surveys. Its organization is: 6 generals; 33 majors, lieutenant-colonels, and colonels; 150 cornets, lieutenants, and captains; 170 classed topographers; 236 topographers, of sergeant's rank; 42 apprentices.

The main divisions of the work of a European state survey are usually three, the triangulation, the topography, and the chartography. When it is practicable, the triangulation precedes the topography, and includes the primary, secondary, and tertiary triangulations and their computations.

If the triangulation points thus determined are numerous, as in the Prussian surveys, additional triangulation by the topographer will not be needed; when, as in Austria, comparatively few points are determined, the topographer will have to base on them a smaller triangulation for his detailed work.

The topographers having been furnished with the positions of certain points within the area to be covered by one of their topographical sheets, make a survey of that area, whose amount of detail will depend on the scale or object of the survey. Their work includes the determination of the required level-curves.

The topographers' sheets go to the chartographic division, whence they are either reproduced on the same scale or reduced to a smaller scale, and the maps resulting from them are published.

METHODS.

It is only within the present century that the methods of geodetic and topographic surveying for large areas have reached high precision.

Previously the chief spur to the production of accurate maps was their necessity for military purposes. In some states progress beyond this need has scarcely been made as yet, and the maps give no more detail than is needed for the movement of troops; in others, and notably in Great Britain and Germany, the progress in civilization, the needs of the government, and the dense population have required and have obtained the adoption of systems of topographical survey and publication, which are sufficient for all rational demands.

Aside from the military uses of maps, uses that in Europe must long be among the most important, the increasing intelligence of man in civilized countries demands an accurate knowledge of the earth's surface in his vicinity; a surface that, while slightly modified by his action upon it, yet retains the same principal features from age to age, so that one good survey, with slight occasional corrections, will suffice for an indefinite period.

Where the survey is on a large scale it serves another purpose, by giving, with sufficient accuracy for the imposition of taxes, the areas of all estates, and may, indeed, be made a basis for land-titles. This, however, requires a larger scale than is necessary for ordinary purposes. In England, such maps, called parish plans, are on a scale of $\frac{1}{2500}$. In many European states, cadastral surveys have been made frequently without connection with a topographical survey, their object being the proper apportionment of land-taxes.

Again, when an accurate survey of a country is made, it will aid in the preliminary examinations for works of engineering, such as railroads, canals, river improvements, although no general survey could properly give the detail necessary for the final location or construction of such works.

In nearly all the European states the area over which the survey extends is covered by a net or chains of triangles of large size, the lengths of whose sides vary from 10 to 100 miles, and depend on bases measured with the highest precision that it is practicable to reach; their probable errors not exceeding about $\frac{1}{300000}$ part of their lengths. In some states all the angles of this net are observed with extreme precision, so that the probable error of any angle shall not exceed a few tenths of a second; in others, as in Italy and Spain, certain chains of triangles, 100 or 200 miles apart, running north and south and east and west, thus forming large quadrilaterals, are observed with the greatest precision, the intermediate triangles receiving less care. At the vertices of several of the triangles accurate determinations of latitude and longitude are made, and the azimuth of a triangle side is determined. The heights of the ground above the level of the sea at all vertices are found either by levelings of precision, or trigonometrically. The positions of these vertices are thus accurately known in latitude, longitude, and elevation; they are the precise reference points on which all the inferior points depend.

Starting from the triangle sides of the primary triangulation, the interior of each such triangle is cut up into a smaller triangulation, called secondary, and the secondary triangles, if necessary, into still smaller ones, called tertiary. The vertices of the tertiary triangulation are the guiding points of the topographer; on them he bases his sheets.

Thus, in Austria two or three such points at least are required for every sheet covering 7½ minutes of latitude and 15 of longitude, on a scale of $\frac{1}{25000}$, with one or two additional ones on the sheet, but perhaps outside of the border. This gives one point for each 60 square kilometers, (24 square miles.)

In the Prussian surveys, ten trigonometrical points are required for each fifty-six square kilometers, (22 square miles.) Scale of detail sheets $\frac{1}{25000}$.

In Italy, the scale used being $\frac{1}{50000}$, one trigonometrical point is determined for every 25 square kilometers, (10 square miles.)

The heights of these points are also determined and given to the topographer, who bases on them his level or contour curves.

The determination of points on which the topographical survey depends has now been explained. If possible, those determinations should be made in advance of the topographical work; where that is impracticable, the topographer must leave permanent marks in prominent positions, which are afterward determined from the triangulation.

On the Continent, the topographical work is done mainly with the plane table, the amount of detail introduced depending on the scale adopted. Thus, in Prussia, where the scale of the plane-table sheets is 1 : 25000, all necessary detail can be given. Roads, paths, mills, detached houses, important fences, streams, ponds, forests, bridges, mines—all can be shown. When the scale is diminished to $\frac{1}{50000}$, as in Italy, a part of this detail must be omitted, and still more when the scale of publication is diminished, as in Sweden, to $\frac{1}{100000}$.

In all the best modern surveys, even when hachures are used to give pictorial effect, the relief of the earth's surface is shown by level or contour lines, at elevations differing with the precision of the survey.

In the Prussian sheets, scale $\frac{1}{25000}$, the level curves are 20 or 25 feet apart in elevation. The Swiss sheets, scale $\frac{1}{25000}$, give them 10 meters apart. In the Austrian surveys, at least eight heights are determined in each square kilometer for the scale $\frac{1}{25000}$ and seventeen for the double scale. The level curves are drawn at either 20 or 100 meters apart.

In the publication of the results of surveys, the scale $\frac{1}{25000}$, adopted by Prussia throughout and by Switzerland except for the most mountainous area, appears sufficient for all ordinary purposes. It permits the measurement of distances to within 15 feet. It gives much more detail than the scale of $\frac{1}{63360}$, at first adopted for the British maps; and their map now being published on a scale of 6 inches to the mile, or $\frac{1}{10560}$, while not large enough to give well the boundaries of estates, yet requires about six times as many sheets as the scale $\frac{1}{25000}$ would do.

The scale $\frac{1}{25000}$ furnishes also an admirable basis for detailed geological work, enabling the geologist at once to place on maps of sufficient detail the results of his labor, as is being done in Prussia. Indeed, the general topographical and geological maps of that country now in progress present to us a standard of excellence which can only be attained after many years.

The detailed sheets need combination for general use into maps of a smaller scale. General Dufour adopted $\frac{1}{100000}$ for his excellent map of Switzerland, and the same scale is adopted for the general staff-map of Prussia, derived from the $\frac{1}{25000}$ sheets.

In reference to the cost of these surveys per square mile, save in the case of Prussia, there is little information. In that country there are about 200 square Prussian miles (4,380 square English miles) covered annually by triangulation, costing $78,000, gold. The topography covers the same area per annum, and, with chartography, costs $117,000, gold, per annum. Dividing the total expense, $195,000 gold, by 4,380, we have $44 gold per square mile as the cost of the survey, exclusive of the salaries and allowances of officers. In Switzerland, much of the topography is done by contract, at the rate of 700 or 800 francs per square Stunde, or $16 to $18 gold per square English mile. The cost of

triangulation, revision, and publication would have to be added to this. Half the cost of the new Swiss survey is borne by the confederation and half by the cantons.

Publication on the scale of the field-sheets only takes place when some society or person agrees to bear half the expense. Austria expends annually about $490,000 for her surveys, but the area covered is not known. It is stated that in the Austrian surveys an officer experienced in topography can, with the aid of two or more soldiers, survey in the six summer-months, on a $\frac{1}{25000}$ scale, from 350 to 500 square kilometers, (140 to 190 square miles,) drawing the same in colors during the winter.

Schiavoni, in Principii di Geodesia, states that a topographer in six months can complete 81 square kilometers, the scale being $\frac{1}{20000}$. The wide difference in these estimates is doubtless due in part to difference in precision of the work, although the scales are nearly the same.

A writer in the North American Review of July, 1875, estimates the total cost of the ordnance-survey of Great Britain up to that date at about $20,000,000, in gold, and the area at 111,000 square miles. This would give a cost of $190 per square mile, the work not yet being complete. It should be remembered that it includes many publications on scales larger than $\frac{1}{25000}$.

Taking the Prussian survey as a model and recollecting that the cost, $44 per square mile, previously stated, does not include the pay of officers, nor (probably) the cost of the Geodetic Institute, which has charge of the primary triangulation and astronomical work, these two omissions, perhaps, increasing the cost of the work to $60 or $65, it is very doubtful if similar work in this country, on account of the greater cost of labor, both skilled and unskilled, could be done for less than $100 gold per square mile.

If a lower standard of accuracy were adopted, such as determination of but one triangulation-point in 25 or 50 square miles, level curves 100 feet apart, field-sheets on a scale of $\frac{1}{50000}$, and published maps on a scale of $\frac{1}{100000}$, the cost might perhaps be reduced to $50 gold per square mile. For level, thickly-settled areas, with numerous telegraph-lines, the cost of the first and less precise maps might be further reduced by substituting astronomical for trigonometrical determinations of the guiding-points. But when at last good topographical work was to be done, trigonometrical points would still be necessary.

Since the General Government, for military and administrative reasons, is interested in these surveys, it should bear a part of the expense. That part might well be the execution of the triangulation for any State that was prepared to make a topographical survey. A triangulation, giving points not more than five or ten miles apart, whose positions were accurately known and permanently marked, would establish firm bases on which all future topography carried on by the States would safely rest. If any town or county desired greater precision in its topography than that adopted as a general rule for the State, the greater precision should be given upon its paying one half the additional cost. When, at any subsequent time, a given locality desired a new and better map, a resurvey, based on the same permanent trigonometrical points, could be made without being affected by the inaccuracies of the neighboring surveys, no errors being propagated beyond the nearest of those points.

Such a plan would involve no large errors, even when the topographical survey was inferior; it would admit of indefinite increase in precis-

ion of detail for any locality, as towns or counties desired that increase and were prepared to meet the expense.

The advantage of placing the triangulation in the hands of the General Government is that its execution would be systematic and precise, avoiding the confusion of methods and uncertainty of accurate results inevitable if there were as many heads concerned in it as there are States in the Union, each largely controlled in his methods by the varying liberality or parsimony of State appropriations.

The triangulation, if once well done, is done forever, and it is more economical not to do it at all than to do it badly.

In its execution, equal precision in the measurement of all the primary triangles would be unnecessary. Chains several hundred miles apart, running along meridians and parallels, (except when they followed mountain-ridges or sea-coasts,) should have their angles measured with the highest precision, so that their results might be available for determining the dimensions of the earth. The interior of the huge quadrilaterals thus formed would be covered with triangles measured with an accuracy less, but still ample for all mapping purposes.

Such a plan, giving, at once, final accuracy in the controlling points and permitting indefinite increase in the representation of the detail around them, furnishing a skeleton to which all local surveys could be fitted, till the whole was complete, would at least supply us with maps of our country that would be creditable and that could be compared with those of other civilized nations.

Only the richer and more thickly-settled States could undertake the topographical survey at present; its extension over the United States would require a century.

Very respectfully, your obedient servant,

C. B. COMSTOCK,
Major of Engineers and Bvt. Brig. Gen.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

CHAPTER II.

§ 1.—THE ORDNANCE-SURVEY OF ENGLAND.

METHODS.

Base-lines are measured with the Colby compensation-bars. The compensation-bar consists of two bars, one iron, the other brass, each 121″.5 long, 0″.5 broad, 1″.5 deep, laid parallel to each other 1″.125 apart and firmly connected at their center by two small transverse steel cylinders. At each extremity of the bars is a metal tongue, 6″.2 long, so connected by pivots to the bars as to admit freely of any expansion or contraction and yet be quite immovable otherwise. On a silver pin at the extremity of each tongue are marked the compensation-points. This compound bar is inclosed in a box, from which project the tongues carrying the compensation-points.

The complete set consists of 6 bars. The interval between the adjacent compensation-points of two bars lying in line for measuring is brought to exactly six inches by means of a compensation-microscope.

Primary triangulation is executed with theodolites having 36, 24, or 18 inch horizontal limbs, divided by dots into spaces of 10′ and provided with micrometer-microscopes for reading.

By means of a secondary triangulation the principal triangles, having sides 20 to 60 miles long, are subdivided into triangles having sides about 5 miles long. This work is done with a 12-inch theodolite.

By the parish or tertiary triangulation the 5-mile sides of the secondary work are subdivided by a net-work having sides of about one mile. In this work a 7-inch theodolite is used.

The detail-work, called field-surveying, is based upon the tertiary triangulation, and in it all boundaries of counties, parishes, townships, and boroughs, roads, canals, streams, fences, houses, divisions between cultivated and uncultivated land, the edges of ravines and precipices, and the outline of masses of outcropping rock are located.

In the cultivated districts the detail-surveying is done with the chain alone. The sides of the tertiary triangles, the lengths of which have been determined by computation, are chained, and the triangles are subdivided by chained lines from which the details to be located are fixed by intersection with the chained lines or by offsets from them. Traversing with a 5-inch theodolite is used, but only when the surveying by right lines would be attended with complication and difficulty, as in the case of a crooked river, at the bottom of a ravine, or in surveying paths or other details through a wood.

In the uncultivated and wooded districts and in the highlands, the surveying is principally performed by traverse or by a combination of traverses and right lines depending on them. The district is divided into blocks bounded by roads, rivers, or county-lines, and general lines of traverse are run starting from trigonometrical stations so as to embrace a whole block and close on the starting-point, thus checking both the azimuth and distance. The general lines of traverse are also connected with every convenient trigonometrical station by a closing angle and distance, and from all trigonometrical stations closed on, when practicable, angles are taken to at least three surrounding stations and to one or more conspicuous permanent objects between them. Intermediate or cross traverses are then proceeded with, starting from and closing on previously established pickets of other traverses on the same meridian, the angle of the former station being always retaken at closing; and in case of more subsidiary traverses made for fixing isolated objects some check-tie is given, such as a return-distance to some other picket on the traverse started from.

In surveying by chained lines the field-party consists of 1 surveyor and 1 chainman; in surveying by traverse, of 1 surveyor and 2 laborers. It is customary to form surveying sections of from 8 to 12 surveyors, in charge of a non-commissioned officer, whose duties are to issue the printed forms of notice, extracts from the acts of Parliament, to the owners of property and others, of the intention to enter upon their lands for the purposes of the survey; to lay down a standard length on a suitable level spot from the standard-chain with which he is supplied, and to parcel out the triangles to the several surveyors; to visit the surveyors in the field and test the accuracy of their work. The surveyors' note-books are regularly inspected by the superintendent to see that the work is properly closed, the diagrams kept up, and all references supplied. All notes are kept in ink, no interlineations of figures or erasures with a knife are permitted, and all alterations in the notes must be supported by the initials of the surveyor.

The plans of the populous, cultivated, and mineral districts are drawn upon the scale of $\frac{1}{2500}$; the highlands and other partially-cultivated and thinly-peopled districts on the scale of 6 inches to 1 mile.

The notes and diagrams of field-surveys are sent to the office to be

plotted and checked by the triangulation; when the discrepancy in chain-work exceeds 1 in 500 the diagram is returned to the superintendent in the field for correction by resurvey. The surveyors are paid by the piece, so much per acre, and all resurveys and corrections must be made at the expense of the surveyor.

After the work is plotted and checked a tracing is made for examination on the ground. The examiner is required to verify the work by judicious intersections, so that the different portions of detail shall mutually prove each other; he fixes the location of trees, footpaths, and all other ornament, supplies the names of hills, streams, houses, and bridges, and collects much of the detailed information given on the ordnance-survey maps.

The traces, having been scrutinized and approved by the examiner, are given to the draughtsman, who transfers all the detail and corrections to the original and then pens in the outline and detail. Types for letters and figures and a variety of stamps for trees, woods, and different characters of ground are used to expedite the work of the draughtsman.

The plans, as they are completed, are subjected to a close office-scrutiny by a competent examiner, who compares the plan with the tracing and sees that the plans are accurately drawn in every respect.

A personal examination of the plans on the ground is made by the officer in charge at this stage, after which they are forwarded by groups to the officer in charge of the leveling, to have the levels inserted, and they are subsequently examined with all the documents complete at the office at Southampton.

Leveling.—The general mean level of the sea for England was obtained by tidal observations at 32 different stations. The means found at each station were connected by leveling and referred to the datum-plane, the height of mean tide at Liverpool. In this primary leveling a series of levels were established along the principal routes of communication through the interior of the country, to serve as a basis for subsequent leveling operations of a more detailed kind, called secondary leveling, which provides, by the leveling and contouring operations, about 1 linear mile of leveling to every square mile, establishes bench-marks and contours for every 100 feet of altitude, up to 1,000 feet above the sea, and determines the height of every trigonometrical station. In the primary leveling the accuracy of the work was checked by again leveling each line backward. In the secondary leveling, the work is checked by closing on the primary work. The limit of closing error is 0.01 foot per mile in long lines. The relative altitude of two stations is determined by measuring the angle of elevation from one station to another by reciprocal zenith-distances or by the usual operations of spirit-leveling.

Contouring.—For this work a 5 inch theodolite is used, and contour-lines are traced on the ground and marked with pickets. The leveler runs a level line from a bench-mark near the required altitude until the contour to be traced is found; then the rodman, with his target set to the height of the instrument, moves along the contour-line as directed by the leveler and marks the points determined with pickets.

When a sufficient length of the contour is marked, the contourer makes a survey of it, plotting his work on a projection furnished him as he proceeds on the ground. This work is verified by an examiner, who again traces the contour and verifies or corrects its location by running the line in the opposite direction.

Hill-sketching.—The object of this work is to produce delineations of

the form and relative altitude of the ground, to be used as data in the brush-work studies required for the guidance of the hill-engraver. The sketcher is furnished with a projection, on which the contours are traced, scale 6 inches to 1 mile, a prismatic compass, protractor, and scales for hill-sketching. Points are located for intermediate contours by bearings; distances are determined by pacing. In sketching, the horizontal system is used for slopes less than 45° and the vertical system for slopes greater than 45°. The work of the hill-sketcher is examined and verified by an officer on the ground, and the sheets are then given to the draughtsman for reduction to the scale of 1 inch to 1 mile. In the reduction, the hill-sketches are made in India ink with a brush. When complete, this reduction is given to the engraver.

Photographic reductions.—The ordnance survey-plans, scale $\frac{1}{2500}$, are reduced to the scale of 6 inches to 1 mile by photography, and silver prints of the reductions are used by the copper-plate-engraver.

Plans to be reduced by photography are prepared with that view. Lines are made somewhat thick, and are drawn in rich black ink; houses are tinted red; waters, blue; roads are left uncolored. A camera, with plate $16\frac{1}{4}$ inches square, and Dullmeyer lens 3 inches diameter, 24 inches focus, is used. This gives a field of the size of the plate, with good definition over the whole of it, with practically no distortion. The plan is mounted on a stand properly adjusted with respect to the camera, and its image is made to cover a figure on the glass equal and similar to that formed by the marginal lines of the plan drawn on the scale to which it is to be reduced. Proper adjustments are provided to secure the required position of the plan and camera. Plate-glass is used for the sensitized wet collodion-plate; and it is mounted so that the collodion film can be made to take the exact place occupied by the ground-face of the focusing-glass. The negatives and prints are produced by the usual methods.

Photographic views published in connection with the ordnance-surveys have been produced by the use of dry plates prepared by the Tannier process. Many plates prepared in this manner have been used after six months with good results. Fair results have been obtained with dry plates four years after their preparation. The exposure required is about four times that necessary for a wet plate. The plates have been kept more than a month between exposure and development without any trace of deterioration.

Engraving.—The 6-inch maps are engraved on copper plates 36 × 24 inches.

The corners of the sheet and the trigonometrical points are first pricked on the copper plate by a scoring-machine, furnished with graduated scales read by verniers. The plate is then removed from the scoring-machine and placed on an iron table heated by gas, while a wax-ground is laid upon it. When this has been done, the corresponding points on the margin are joined with fine ruled lines, by which the sheet is divided into sixteen equal rectangles. Tracings of the photographs to be engraved are made with lamp-black, and each, being a sixteenth part of the 6-inch sheet, fits into one of the rectangles drawn on the copper plate, and is transferred to the wax-ground by rubbing with a steel burnisher, after which the plate goes into the hands of the engraver. The outline is first engraved, and then the writing, afterwards the ornament, rocks, woods, water, and contours. Figures are punched with steel type; trees and woods, with steel punches. Parks and sand are ruled with a dotting-wheel; buildings are shaded with a ruling-machine. Hills are engraved, on the 1-inch sheets, by etching with acid.

Four proofs are taken at different stages of the work, and each proof is examined and all corrections are made before the sheet is pronounced ready for publication.

Electrotyping.—This process is applied for several purposes :

I. Duplicates of the original engraved plates are obtained, thus saving them from being worn out by constant printing.

II. Alterations can be made in the cast or matrix, in which the details are in relief, much easier than by cutting out from the original plate.

III. Parts of several engraved plates may be used to form a single plate for printing from.

IV. Copies are taken of the engraved plates in different stages of their progress and with different classes of information engraved upon the different copies. Thus the 1-inch map of Great Britain is published in outline with contours, another with hills complete but without contours, a third with the geology engraved, &c.

In producing the electrotype-plates a Smee battery, single cell, is used; zinc plates $2' \times 2'\ 4''$, silvered copper plates $4\frac{1}{2}''$ wide, six of them being placed together in a frame presenting a surface equal to that of the zinc plate. With this battery $\frac{1}{3}$ of a pound of copper to one square foot of surface may be deposited in 24 hours.

The engraved plate is washed with cyanide of silver, and afterward with a solution of iodine in alcohol, and then exposed to the sun. A composition of wax and tallow is laid around the plate to prevent deposit on the edge. The plate is then put in the electrotyping-cell and a sheet of copper larger than the plate is laid over it and separated from it by 1 inch. The wires are attached, the matrix is produced, and a duplicate is obtained from the matrix by the usual process. The duplicate is next hardened and finished and may then be used for printing.

Zincographic printing.—In this process zinc plates $\frac{3}{16}$ of an inch thick are used. The plate is prepared by scraping it evenly until all irregularities and other defects are removed, is then ground with pumice-stone and water, and smoothed with a piece of steatite. A grained surface is given to the plate by rubbing over it molding-sand and water with a zinc muller. The plan to be zincographed is traced in lithographic writing-ink on tracing-paper thinly coated with starch. The tracing is put for a few minutes in a dampening-book moistened with water and nitric acid to neutralize the alkali in the soap of the ink. Next, the tracing is put between sheets of paper moist with water only, and is left to expand to an extent equal to the amount of contraction which will take place in the wet paper on which the maps are printed, about $\frac{1}{4}$ of an inch in 3 feet. The damp tracing is laid face downward on the prepared surface of the zinc plate, a sheet of paper is placed over it, and the whole is passed through the lithographic press several times. The covering-paper is removed, the tracing is dampened and carefully peeled off the surface of the zinc. The outline will be found on the zinc in ink, which the starch has prevented from soaking into the paper. The face of the zinc plate is now washed with hard water and a sponge to remove the starch, and is then etched with a preparation of phosphoric acid to remove dirt and finger-marks and give a slight relief to the parts protected by ink. A roller, charged with lithographic printing-ink, is next passed over the zinc plate, which is kept moist with a wet cloth. The ink only adheres to the parts where the writing-ink has been absorbed. The plate is now ready for use in printing.

The zincographed impressions are colored; water, blue; buildings, carmine; roads, raw sienna.

Photozincography.—In this process a negative of the plan or map to

be reproduced is taken on a glass plate and the silver deposit is blackened with corrosive sublimate and ammonium hydrosulphate; a sun-print is taken from the negative on paper, coated with gelatine and bichromate of potassa, which surface, when exposed to the influence of light, is insoluble in water at a moderately high temperature.

The print is uniformly covered with greasy transfer-ink, and afterward washed with warm water, to dissolve the gelatine unacted upon by light, and so carry away the ink upon it, which will now remain only on the insoluble portions. In this way a print in a greasy carbon-ink is prepared, which can be transferred to zinc or stone in the usual manner. The paper used for the carbon-print should be tough, and have a surface that will remain almost undisturbed when saturated with water.

Anastatic process.—By this process a direct transfer is made from a printed impression to a zinc plate, which is then used for printing. Fresh prints, not dry and hard, may be transferred as follows: The face of the print to be copied is laid upon clean blotting-paper and the back is brushed over with nitric acid diluted with water. The print is then deprived of superfluous moisture by pressure between sheets of blotting-paper, is placed faced downward on a prepared zinc surface and passed through the printing-press. On removing the print the zinc plate is sponged over with gum-arabic, water is added, and the plate is gently washed. The transfer is then charged up with lithographic printing-ink, washed with water, and etched with phosphoric acid and gum-water, and is then ready for use in printing. Alterations may be made by obliteration with steatite, polishing with emery-cloth, and transfer as before. If additions are required, the polished surface is acted on by nitric acid and water, and then the additions can be made with a pen and transfer-ink and be etched as before described.

Old prints, dry and hard, are first softened for transfer by immersion in hot water to which caustic strontia has been added.

Authority.—Methods and Processes of Ordnance Survey, 1875.

Compiled by H. M. Adams, Captain of Engineers.

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§ 2. The Ordnance Survey of Great Britain.

ORGANIZATION AND MAPS.

The data available for this report are the "Report of the Progress of the Ordnance Survey to 31st of December, 1874," and 36 atlas-sheets, which are samples of the various scales employed and of the different styles of publication.

ORGANIZATION.

The following facts appear from the report. The ordnance-survey forms a part of the work of the Royal Engineer Corps, and the present director-general is Lieutenant-General Sir Henry James, R. E. An officer of the Royal Engineers has charge of each of the different divisions of the survey. The areas over which the surveys are being made are divided into districts comprising one or more counties, and the work in each district is under the immediate charge of an officer of engineers stationed in the district.

At the date of the report there were employed upon the survey 19 officers of the Royal Engineers; 4 companies of engineers, consisting of 121 non-commissioned officers, 243 sappers, and 8 buglers; 1,000 civil assistants of different grades, and 448 laborers.

SCALES EMPLOYED AND METHODS OF PUBLICATION.

Numerous scales are adopted for the survey and publication, in order to meet the requirements of the public and of the various departments of the government. The scales employed for the general maps of the country are those of one inch and six inches to the mile, ($\frac{1}{63360}$ and $\frac{1}{10560}$,) and the plans of the whole United Kingdom are being engraved on copper on these scales.

For the purposes of the valuation of property, the survey of all the cultivated parts of England, Scotland, and Wales is made on the scale of $\frac{1}{2500}$, or 25.344 inches to the mile, commonly called the inch-to-the-acre scale. The plans on this scale are called parish-plans, and are made by photozincography, a process discovered by the director-general in 1860. These plans are reduced by photography for publication on the 6-inch scale.

The principal scales adopted for the plans of cities and towns are that of $\frac{1}{500}$, or 10.56 feet to the mile, for towns of over 4,000 inhabitants, and that of $\frac{1}{1056}$, or 5 feet to the mile, for smaller towns, although the plans of a few towns have been surveyed and drawn on scales of 1 foot, 2 feet, and 20 inches to the mile. These plans are either engraved or zincographed. In addition to the above-mentioned general maps and plans, special plans, as required, are made for the use of the governmental departments, the courts, &c., and the expenses incurred in their preparation are re-imbursed to the survey.

Geological lines and references have been engraved on some of the 6-inch and 1-inch sheets. None of these, however, are contained among the sample-sheets.

The various publications are sold to the general public at moderate prices. The receipts from these sales for the year 1874 amounted to over £8,000.

STATE OF THE SURVEY AND PUBLICATION AT THE CLOSE OF THE YEAR 1874.

England and Wales.—Area, 58,000 square miles. Surveyed on the 6-inch and $\frac{1}{2500}$ scales 26,358 square miles. Surveyed during the year 1874 1,456 square miles. Published on the $\frac{1}{2500}$ scale 11,527 square miles, and the 6-inch scale 16,678 square miles. On the 1-inch scale the whole map was completed and published, constituting what is called the old series. A new series of maps on the 1-inch scale on an improved projection and with a more uniform system of numbering of the sheets is now in course of publication. Plans of 95 towns on the $\frac{1}{500}$ scale and of 61 towns on the 5-foot scale, had been published, and those of 19 towns had been surveyed and drawn, but not engraved on the $\frac{1}{500}$ scale.

Scotland.—Area, 30,000 square miles. Surveyed on the 6-inch and $\frac{1}{2500}$ scales 28,858 square miles, of which 1,029 square miles were surveyed during the year 1874. Published on the $\frac{1}{2500}$ scale 10,908 square miles; on the 6-inch scale, 19,850 square miles; and on the 1-inch scale, 14,394 square miles. The surveys of the towns of Scotland were completed, and the plans of 45 towns on the $\frac{1}{500}$ scale and of 15 towns on the 5-foot scale had been published.

Ireland.—Area, 32,813 square miles. The survey on the 6-inch scale had been completed and the map published. The maps of ten counties had been revised and new editions of them published. The whole map on the 1-inch scale had been engraved and published in outline, and the

ORDNANCE SURVEY OF SCOTLAND — **PART OF—SHEET 38**

Scale, 1: 63360.

1 — 0 — 1 — 2 — 3 — 4 Miles

No.s of the adjoining Sheets of the One Inch Map.

45	46	47
37	38	39
29	30	31

ORDNANCE SURVEY OF IRELAND

Part of SHEET 130.

Scale $\frac{1}{63360}$

Nos. of the adjoining Sheets of the One Inch Map

120	121	
129	130	
138	139	

engraving of the hills was in progress. The area published with the hills is 16,694 square miles. Plans of 74 towns on the 5-foot scale, of 1 on the 2-foot scale, of 14 on the 20-inch scale, and of 12 on the 1-foot scale had been drawn, but not published. Plans of 8 towns on the $\frac{1}{500}$ scale had been surveyed, but not drawn.

DESCRIPTION OF THE MAPS AND PLANS.

The following details respecting the maps and plans are obtained from an examination of the 36 specimen-sheets and from the index-sheets published in the report for 1874.

One-inch scale.—The old series of the map of England on this scale is published in two styles, which differ only in the manner of representing the relief, which is indicated in the one by level curves and in the other by hachures. Each sheet represents an area of 26′ 50″ in longitude (about 18 miles) by 10′ 25″ in latitude, (about 12 miles.) The projection-lines do not extend across the sheets on any of the ordnance-survey maps. On the sheets of the 1 inch scale the border is divided into 10″ spaces. The maps contain a great deal of detail, the topographical features being indicated by the usual conventional signs. They show the rivers, streams, lakes, marshes, mountains, valleys, moors, forests, villages, isolated houses, triangulation-stations, (with their altitudes,) railroads, turnpikes, common roads, ruins, ancient settlements, boundary-lines of counties, townships, and parishes.

The nomenclature is very detailed, the names of isolated houses or of their owners and the local names of hills and other accidents of the ground being given. The level curves are 100, 250, or 500 feet apart, according to the nature of the surface.

There are no sheets of the new series of the 1-inch map of England with the samples sent, but the index-map shows that the new map will consist of 360 sheets, each representing an area of 18 by 12 miles.

The map of Ireland consists of 205 sheets, which only differ from those of the map of England in having on the margin of each two diagrams, the one an index to the 6-inch maps on the sheet, and the other showing the numbers of the eight adjoining sheets of the 1-inch map.

The map of Scotland and the neighboring islands will consist of 131 sheets. The sheets are larger than those of the corresponding maps of England and Ireland, each representing an area of 24 by 18 miles, but in other respects they are entirely similar to those of the map of Ireland..

Six-inch scale.—The sheets on this scale appear to be numbered by counties. Each sheet represents an area 6 by 4 miles. The latitude and longitude are shown on the border, which is divided into 1″ spaces. Four scales are given, viz, of feet, miles, chains, and perches. The numbers of the adjoining sheets are indicated by letters on the margin at each side. In addition to the features shown on the 1-inch map, upon this appear all houses, barns, outbuildings, &c., with their correct outlines, wells, fences, hedges, bridges, telegraph-lines, &c. The areas of the townships and parishes of Great Britain and of the town-lands of Ireland are engraved upon the sheets.

The relief is shown both by level curves at distances of 25, 50, or 100 feet apart, according to the nature of the ground, and by figures placed on the roads giving the altitudes for about each 1,000 feet of distance, and also by figures giving the altitudes of bench-marks made on walls, buildings, &c.

The names of roads, of the principal streets and buildings in the cities and towns, of bridges, (the materials of which they are constructed,

whether wooden, iron, or stone, being also stated,) of farms, parks, woods, hills, detached houses, &c., are given with great minuteness.

$\frac{1}{2500}$ *or* 25.344-*inch scale.*—Each sheet represents an area of $1\frac{1}{2}$ by 1 miles. The numbers of the adjoining sheet are shown by the method used in the 6-inch maps. Scales of miles, chains, feet, and in some cases of links and yards are given. Latitudes and longitudes are not indicated. These plans contain essentially the same natural and artificial features as the 6-inch maps, but the amount of detail is of course greater, the scale being sufficiently large to admit of the accurate location of individual trees, &c. Each subdivision of the land is numbered, the numbers referring to corresponding numbers in area-books which are published in connection with the plans. There are no level curves, the relief being indicated by numbers giving the altitudes of points at short distances apart on the roads, and by the heights of bench-marks. These plans are published both plain and in colors.

$\frac{1}{1056}$ *or* 5 *foot scale.*—Each sheet represents an area of 3,170 by 2,120 feet. Scales of feet and links are given. The numbers of the adjoining sheets are shown on the margin, which also contains a diagram indicating the position of the sheet on the $\frac{1}{2500}$ maps. These sheets are detailed plans of the cities and towns for which they are made, containing accurate representations of the outlines of buildings, streets, railroads, parks, &c., and the positions of fire-plugs, lamp-posts, &c. The names of public buildings, churches, (with the number of their sittings,) hotels, manufacturing establishments, and other large buildings are given. The relief is indicated in the same manner as on the sheets of the $\frac{1}{2500}$ scale. The plans are issued both plain and in colors.

$\frac{1}{500}$ *or* 10.56-*foot scale.*—Each sheet represents an area of 1,600 by 1,060 feet. Scales of feet and links are given. These plans appear to contain about the same features as the 5-foot plans, the only difference being that the larger scale shows more clearly the various details represented, and admits of a more minute naming of the different buildings, &c. The two specimens of these plans are both colored.

Authorities.—Ordnance Survey Report 1874, and 36 maps.

Compiled by Lieut. P. M. Price, United States Engineers.

CHAPTER III.

§ 1. NOTES ON PRUSSIAN SURVEYS.

In 1864 the survey of the six eastern provinces of Prussia was undertaken, their total area being about 4,200 square Prussian miles, (one Prussian equals 4.68 English miles.)

The time then estimated for the completion of the work was ten years, but the plan was subsequently extended to include the whole state.

The geodetic and astronomical work is under the charge of General J. J. Baeyer, who directs the Geodetic Institute and the central bureau for the European measurement of degrees, (*Gradmessung.*)

The trigonometrical, topographical, and chartographic operations are under the general staff of the army, the present head of the land-survey being General Von Morozowicz.

The aim of the triangulation is to furnish for all time a net that shall be accurate enough for any demands that may be made upon it, even if surveys should be desired on a scale so large as $\frac{1}{2000}$. The sides of the small triangles furnish bases for detailed topographical work.

The triangulation of the first class consists of chains of large triangles running through the area to be surveyed. Its angles are measured with theodolites having circles not less than 10 inches in diameter by twenty-four pointings at each object. Objects are pointed at in the order A, B, C, D—D, C, B, A, and between each such set of pointings the horizontal limb is turned 30° in azimuth. The probable error of any triangle side must not exceed 1:100000.

In the triangulation of the second class the triangle sides usually vary between $1\frac{1}{2}$ and 2 Prussian miles in length. The angles are read with 8-inch theodolites, giving seconds, twelve pointings being obtained on each object. The probable error in the lengths of the triangle sides must not not exceed 1:50000.

The detail triangulation (of third and fourth classes) is based on the triangulation of the second class. It must give nine or ten points at least in each Prussian square mile, (equals 22 English square miles.) The angles are read by 5-inch theodolites, giving seconds, and the probable errors of its sides must not exceed 1:25000.

The triangúlation of the first and second classes consists of chains; that of the third and fourth classes must, if possible, be a continuous net, covering the whole area to be surveyed.

The angles of the triangulations of the first and second classes are adjusted by Bessel's method.

The heights of all triangle points are determined by a combination of ordinary and trigonometric leveling.

All triangulation points are marked by cut stones.

The processes of triangulation have now been described. The maps resulting from the work are of two classes: 1. Those on the scale of 1:25000, which are reproductions of the original plane-table sheets on the scale 1:25000; each of these plane-table sheets covers the area included by two meridians 10 minutes apart and two parallels 6 minutes apart. 2. Maps on a scale of 1:100000, covering an area of 15 minutes in latitude by 30 minutes in longitude, are derived from the 1:25000 maps.

The topographical work consists in the production of finished plane-table sheets on a scale of 1:25000, and is based on the nine or ten trigonometrical points determined in each Prussian square mile. As one of the sheets covers an area of $2\frac{1}{4}$ such miles, it has on it about twenty such points.

These trigonometrical points are plotted on Whatman's paper, which is fastened by its whole under surface to a plane-table with white of egg. The alidade of the plane-table has a vertical circle and stadia wires, so that with a stadia distances and elevations are readily determined. While for the important points prosections and resections and the three-point problem are used for fixing points on this plane-table sheet, much of the work is done with the stadia.

For important points the plane-table is oriented only on other well-determined points. In less important work, in a country free from local attraction of the magnetic needle, this is used for orientation.

All roads, streams, bodies of water, streets, isolated houses, forests, tax-boundaries, hedges, gardens, terraces, and, generally, all objects either important in themselves or in a military point of view are represented that the $\frac{1}{25000}$ scale will express. For many smaller objects conventional signs are established. Woods are classed and represented as leafy, needle-leaved, (coniferal,) and mixed.

It is assumed that in general, even in broken ground, a sufficiently accurate representation may be obtained when the stadia-points have

an average distance from each other of about 200 meters. Intermediate details are sketched on the plane-table without use of the alidade, by setting the table up approximately at each stadia-point and by pacing. The permissable limits of error in distances on the plane-table sheet of any point are from 10 to 20 meters, and in elevation from 1 to 2 meters.

The ordinary difference of elevation of contour curves is 5 meters, but when, for military purposes, more detail is needed, curves $2^m.50$ or $1^m.25$ apart may be used. Curves of 5 meters and less are represented by broken lines, of 10 meters by a full line, and of 20 meters by a heavy line. Their heights are given from the sea-level.

Much of the plane-table sheet is inked in the field; but parts which are common to another sheet are not inked until after a comparison with that sheet is made in the office. The sheet is then completed and illuminated for photographic reproduction. This illumination consists in applying pale tints of color, seven in number, to certain parts of the plane-table sheet, so as to give more prominence to water, roads, stone, buildings, court-yards, forests, marshes, &c. On these sheets relief is given by contour lines. On certain rough copies of them, for military use, the tintings of color are stronger, and hachures may be added to the contour lines. For a scale of $\frac{1}{25000}$, when hachures are used, there are 40 in 3 centimeters. They express every 5 degrees of slope from 0° to 45°, and the ratio of the width of the black line to its white inter-space, when x° represents the slope, is $\frac{x^\circ}{45^\circ - x^\circ}$

Lehmann's method of representing slopes uses only full straight lines for hachures. In General Maffling's modification some of these lines are broken and some waving.

On the $\frac{1}{100000}$ maps Maffling's system is used for slopes of 5° and 10°, and Lehmann's for greater ones.

General Bæyer has proposed to replace the plane-table for all precise topographical work by the theodolite and stadia; and this has been done, partially or completely, in the cadastral survey of Schwarzburg-Sonderhausen.

Oberforstmeister Michaelis states that the accuracy was largely increased without increase of cost over that of graphical work. Theodolites have also been used in the surveys in Wurtemburg and Gotha for topographical work; but the plane-table is still in general use.

Two hundred square Prussian miles are covered annually by triangulation and topography.

For 1875, excluding salaries of officers and soldiers, the expense of triangulation was 312,000 marks, and of topography and chartography 470,000 marks; one mark being about 24 cents gold.

In 1874 the cost of the Geodetic Institute was 106,440 marks.

Authorities.—Manuscript letter of Lieutenant General von Morozowicz, chief of land survey, of June 16, 1876, to Count von Moltke; Die preussische Landes-Triangulation; Umgegend von Berlin, Berlin, 1867; instruction für die Topographen der königlich-preussischen Landes-Aufnahme, Heft I. und II., Major Baumann, Berlin, 1876; Letter of Count von Bulow of December 2, 1875.

Compiled by Major C. B. Comstock, Corps of Engineers.

§ 2. Notes on Prussian maps.

ORGANIZATION OF THE SURVEY.

From the letter of Herr Von Bulow to the chargé d'affaires of the United States at Berlin, dated December 2, 1875, a copy of which has been

furnished, it appears that the several branches of the public surveys are in charge of different departments of the Government, as follows:

TRIGONOMETRICAL, TOPOGRAPHICAL, AND CHARTOGRAPHICAL WORK.

This work is entrusted to the general staff of the army.

The trigonometrical department triangulates annually over an area of 200 square Prussian miles, establishing ten points, marked by stones, to the square Prussian mile. (1 Prussian mile is equal to 4.68 English miles; 200 square Prussian miles are equal to 4,380.48 square English miles.) Its personnel is: 1 chief, 6 measurement-directors, (staff officers or captains,) 8 detailed officers, (lieutenants,) 18 upper gunners, (assistant observers.) Besides these there are the necessary office and house personnel.

The cost of the trigonometrical measurements for 1875, exclusive of the salaries and allowances of the officers, was 312,000 marks, (about $78,000 gold.)

The topographical department surveys annually 200 square Prussian miles on the scale of 1:25000, establishing also the level-curves. It also perfects the earlier surveys by annual reconnaissances. The personnel is: 1 chief, 5 measurement-directors, (staff officers or captains,) 20 detailed officers, 10 engineer-geographers, 70 assistant topographers, (upper gunners, gunners, and civil assistants.)

The chartographical department has charge of the publication of the maps both on the original or 1:25000 scale and on the 1:100000 scale, (the so-called general-staff chart.) The published sheets can be purchased through the book-stores. The personnel is: 1 chief, 1 officer, (staff officer or captain,) 1 technical inspector, 11 draughtsmen, 7 lithographers, 1 photographer, 5 printers, 4 printers' assistants, and in addition a number of comparing workmen.

The cost of the topographical and chartographical departments for 1875, exclusive of the salaries and allowances of the officers, was 470,000 marks, (about $117,500 gold.)

GEODETIC WORK.

The geodetic work is performed by the Geodetic Institute, which is under the direction of the ministry for spiritual, educational, and medical affairs. The Geodetic Institute executes the geodetic triangulations, makes the astronomical observations upon the vertices of the triangles, computes the co-ordinates of astronomically-determined points, makes comparisons of measures, and of levelings and water-mark observations for the determination of the relative levels of the European seas, and in addition performs the functions of the "Central Bureau of the European Degrees Measurements."

GEOLOGICAL WORK.

The geological surveys are executed by the Royal Geological Land Institute, which is under the direction of the ministry of commerce, industry, and public works.

TOPOGRAPHICAL AND GEOLOGICAL CHARTS.

Two sheets of the topographical chart and nine of the geological chart, all on the scale of 1:25000, have been sent to this office for examination.

For the purposes of publication and reference, each degree of latitude is divided into 10 equal parts, and each degree of longitude into 6 equal parts, so that each sheet represents an area of 10′ of longitude by 6′ of latitude. The rows of rectangles into which the country to be mapped

is thus divided, are numbered between the even degrees from I to X from south to north, and from 1 to 6 from west to east, and position of each sheet is printed on its margin: *e. g.* $\frac{52^\circ}{51^\circ}$ of latitude, $\frac{29^\circ}{30^\circ}$ of longitude; range VI, sheet 4. The whole series of rectangles is numbered continuously also, and the number of each sheet in this series is printed also on its margin. The numbers of the adjoining sheets are printed on the margin at the four sides. An index diagram is printed on the outside cover of the charts. Two scales are drawn on each sheet, one of schritt and ruthen, (the schritt is equal to 2.47 feet, and the ruthen to 12.36 feet,) the other showing the slope of the surface in degrees corresponding to a given horizontal distance between the level curves.

The topographical sheets represent, by the usual conventional signs, the natural and artificial features of the country, with all the detail which the scale admits of without overloading. They show the rivers, streams, lakes, ponds, marshes, forests, woods, meadows, peat-bogs, mines, railroads, post and common roads, bridges, trigonometrical points with their altitudes, villages, detached houses, mills, toll-gates, brick-yards, lime-kilns, fences, and boundary-lines of provinces and districts. The reilef is indicated by level curves at distances of 20 or 25 feet apart, according to the nature of the ground. The even hundred-feet curves are drawn full and heavy, and their altitudes are written upon them; the intermediate curves are drawn full and light, and their altitudes are not written. When necessary, extra intermediate curves are inserted, and these are drawn broken and light. Abrupt declivities. such as gorges, embankments, &c., are indicated by hachures. Where the country is broken, the exact altitudes of the summits of the hills are written upon them. The names of all the principal natural and artificial features of the country are given with sufficient detail.

The geological charts are made by properly coloring and referencing the above topographical charts. They appear to show very completely and with much detail the geological features of the country. The different formations are indicated by various colors and combinations of colors, and these are further distinguished from each other by being lettered or numbered both on the body of the chart and on the index which appears on the margin. The localities at which borings were made or shafts sunk, the positions of mines in operation, and of those which are not worked points at which fossil animals or plants were discovered, the slope of the strata, the points where faults, slips, &c., occur are all indicated.

A descriptive text is published in connection with the chart.

Authorities.—Letter of Mr. Von Bulow, of December 2, 1875, and 11 maps.

Compiled by Lieut. P. M. PRICE, United States Engineers.

§ 3. MEMORIAL ON THE CREATION OF A GEOLOGICAL STATE INSTITUTE FOR THE PRUSSIAN STATE.

GENERAL UTILITY OF THE GEOLOGICAL EXAMINATION OF THE COUNTRY.

The geological survey of the country, *i. e.*, the exact examination of the inner compos't'on and the constitution of the soil (earth) (*Boden*) of our country, is a problem in which not science only is interested.

Its results, deposited in geological maps and explanatory descriptions,

are also of a direct value to the most important interests of practical life.

In mining, the geological knowledge of the rock-strata is the most important guide to the deposits of useful minerals, and the indispensable counselor for a successful working (*ausbeutung*) of the same.

Agriculture and forest management are not less interested in the geological examination of the country than mining.

An accurate knowledge of the composition of the cultivable ground and of the nature of its subsoil is the basis upon which they are carried on, (*ihres betriebes*,) and a new geological discovery or the finding of new mineral deposits may in the most effective manner influence the development of agriculture.

Reference may be had to Stassfurth, the inexhaustible source of salt for manure and for cattle, (*düngsalz and viehsalz*,) or to the discovery of the phosphorite-deposit in Nassau, or to the strata of lignite, with the discovery of which the development of the sugar-beet industry in many parts of the country is so closely connected.

It will be sufficient only to mention in how great a degree the results gained by the geological work, the pointing out of the building-mortar, cement-materials, &c., benefit building, (*bauwesén*.)

GEOLOGICAL EXAMINATIONS IN FOREIGN COUNTRIES.

The subject of the geological survey and mapping of the country, therefore, has in all civilized countries received the care and attention, not only of science, but also quite particularly of administrations.

England has possessed since the year 1835 an institute endowed with great means, the Geological Survey of the United Kingdom, which is devoted to this subject only.

Austria followed this example in the year 1849 by creating the K. K. Geological State Institute.

In the last years a geological state institute for Hungary was founded in Pesth; in Italy the R. Comitato Geologico d' Italia; and in the kingdom of Saxony, also, ample means have been given by the government, (*landesvertretung*,) a short time ago, for the erection of such an institute.

In like manner British East India, the Australian colonies, and nearly all the States of the North American Union possess special institutes for the geological examination of the country.

In other countries, in France, the South German States, in Sweden, Norway, Russia, this work is not put in charge of a special institute; but it causes a continued activity and partly very considerable expenditures.

IMPORTANCE OF THE GEOLOGICAL EXAMINATION OF THE COUNTRY TO PRUSSIA.

Among all these countries there is not one to which the geological survey and mapping would be of greater importance than to Prussia.

Next to England, it is the farthest advanced in the opening and development of the natural sources of wealth which are concealed within the earth.

Prussian mining and the management of salt works are developed on a large scale and are progressing rapidly; the value of raw production from that source amounted in the year 1870 to 70,500,000 thalers; in the year 1860 to 32,300,000 thalers. The value of the raw production of the

smelting-works in 1870 was 142,500,000 thalers; in 1860 it was 63,550,000 thalers; while the total value of the mining-productions in the Austrian Empire, for instance, amounts to about 20,000,000 thalers, and that of the production of the smelting-works to about 22,000,000 thalers.

On the products of the mines and smelting-works a great industry of the most varied kind depends in Prussia, the productions of which contend for the first place in the market of the world, and which have in a large degree contributed to the foundation of the prosperity which our country enjoys.

Particularly, also, the relation mentioned between geological inquiry and the improvement of agriculture is of special importance in Prussia.

A very large part of the country is covered by a soil which, in consequence of its natural poverty, is very specially in need of the supply of enriching materials, among which may be mentioned lime, marl, gypsum, salts of potash, and phosphorite.

Even the pointing out merely of a solid stone stratum may be of great importance for the economic management (*Wirthschaftlichen Betrieb*) in many of our northern districts as a source of building and road-material.

PREVIOUS RESULTS OF THE GEOLOGICAL INQUIRY IN PRUSSIA.

The importance of the geological examination of the country for all the branches of economic activity has in Prussia been recognized a long time ago, and for a great part of the state a comparatively high degree of knowledge of the geological peculiarities (*verhältnisse*) has been reached just as early as, and even earlier than, in the neighboring countries.

The greater part of the mountain country has been geognostically surveyed and the results represented on geological maps, which were very excellent for the time in which they were executed.

Of the provinces of Rhineland and Westphalia, a general geological map, in 32 sheets, on the scale of 1 : 80,000, has been prepared under the direction of V. Dechen.

Lower Silesia has been examined by G. Rose, E. Beyrich, Roth, and Runge, and drawn in 12 sheets, on the scale of 1 : 100,000.

The survey of Upper Silesia has only been completed a short time ago under the direction of F. Roemer, and represented, also, in a map of 12 sheets, on the scale of 1 : 100,000, which comprises part of the Russian-Polish boundary district.

Besides these general maps of extensive parts of the old monarchy, and some special representations of individual small parts of the same, belonging to the last decennium, we have, as geological representations of somewhat older dates, a map of Hanover, by H. Roemer, in 6 sheets, on the scale of 1 : 100,000, representing the southwestern part of that province; a special map of the surroundings of the city of Hanover, by Credner; a general map of the electorate of Hesse, by Schwarzenberg and Reusse; the geological map of the country of Schaumburg, and some other special maps of smaller groups.

Those parts of the mountain country which have not been newly represented in the geological maps referred to are contained in the older general maps of Fr. Hofmann, of Northwestern Germany, and of L. von Buch, of Germany.

Evidently, therefore, much has been done for the examination of the geological conditions of the greatest part of the mountain country of Prussia, and the results of these examinations have partly been made accessible for everybody by means of good maps.

FUTURE TASKS OF GEOLOGICAL INQUIRY IN PRUSSIA.

It would, however, be wrong to suppose that the work mentioned has sufficiently exhausted the subject for the time being. For, as it is shown by the above statements, new general maps are wanting for some of the most important parts of the country, *e. g.* for Nassau, Hesse, and a large part of Hanover. A very important task, although until now hardly commenced, then remains for the geological state-survey of Prussia—the examination and mapping of the northern plain.

Formerly the opinion obtained pretty generally that the geological examination of districts, the ground of which is formed by loose layers of the so-called diluvial and alluvial deposits, could not be of either scientific or technical interest, because of its too great uniformity, and because where a change is observed in the condition of the deposits, this is only accidental and not of a general character.

Latterly, however, it has become evident that these sands, clays, and marls of this so-called alluvium (*schwemmland*) also divide themselves, just like the layers of the older formations, into different subdivisions, which must be separated according to age and condition, and that the knowledge of the distribution of the different parts are valuable in a scientific as well as technical respect, especially for agriculture and forest management.

The survey and mapping of these territories in a proper manner, for which there are good examples existing in the geological map of the Netherlands by Stanieg, and in the latest works by Dr. Behrend on East Prussia, would show itself to be very beneficial for their industrial development, and be at the same time of great scientific interest.

This would especially be the case if an examination of the older formations, forming the substrata of the diluvium, as also of the tertiary lignite-bearing formation, was, by means of numerous borings, united simultaneously with the examination of the surface.

In the case of such a methodically managed examination of the northern part of the State the discovery of new strata of useful minerals could not fail, leaving aside the other benefits of the survey.

The individual important results of borings obtained in recent times at different points—Sperenberg, Inowraclau, Segeberg—open encouraging prospects in that respect.

With regard to the future problems of the geological state-survey, it must be remembered that even the best of the existing general maps can be recognized only as preparatory work in the direction of a higher end, which must be reached, the attainment of which has only just been entered on.

The enumerated geological maps, namely, as valuable and conscientiously prepared as they may be, are always only quite general geological reviewing pictures, which indicate the limits of strata in general lines only.

They suffice, therefore, in many cases, for the exigencies of science, possibly also for the deduction of approximate conclusions as to the rock-stratification for mining purposes, for a general judgment as to the probability of the occurrence of useful deposits, their continuation, etc.

They are just as little sufficient to satisfy the exigencies of practical life, however, as the requirements of strict scientific accuracy and trustworthiness.

The scale of the existing maps is not nearly sufficient to make a complete geological picture possible.

If the limitation of the formations—and that not only of the main groups, but also of the individual subdivisions, of particular strata of special technical or agronomical importance, or certain occurrences, not very extensive but scientifically decisive—is to be represented on the maps strictly according to reality, it is technically impossible to do this in maps of the mentioned scales.

Considerably greater scales and far more detailed topographical foundations must be used than has been the case heretofore.

The fact that the geological representations could not, in the manner of execution heretofore employed, give such directly useful details, explains why the results of geological examinations have not become known by the public, which is largely interested in them; that, on the contrary, they and the geological maps remained for the main part the property of science.

To supply this want England has first started in the right direction. As the topographical basis for the geological general map of the United-Kingdom—consisting of 435 sheets—the map of the ordnance-survey has been taken, which is drawn on a scale of 1:63360, a scale exceeding that of our 1:100000 general map in surface $2\frac{1}{2}$ times, and therefore admitting of a more correct representation.

Of those districts, however, which show a particularly difficult stratification or such peculiarities that they contain the basis for a greater industrial activity, *e. g.*, the coal-districts, special geological maps are prepared on a scale six times as large as the stated one, viz, 1:10560.

Simultaneously, therefore, an already very clear general map is created, and the requirements of practical life are met with such representations as satisfy all its demands.

To follow the example of England is the problem for the future activity of the geological state-survey in Prussia, which possesses so many analogies with England in regard to the direct influence of the same on economic activity.

PRESENT PLAN OF OPERATIONS FOR PRUSSIA.

The performing of this task has been prosecuted with good results, according to the plan designed 5 years ago for the further geological surveys and mapping.

The principal map is a special map based on the plane-table sheets of the general staff in 1:25000, a scale which is in length 4 times, and in area 16 times, as large as that of 1:100000, heretofore used in preference to the general maps.

As the completion of the special map advances, the results will be newly placed together in general maps.

For the present this system is being carried out in the mountain regions, and the plan has been made so that the geological special map shall first be prepared for those parts of the country of which there exists new staff maps, viz, the province of Saxony, the Harz, the Electorate, the southern part of the Rhenish province, and Nassau.

In proportion to the completion by the staff of new plane-table sheets for other parts of the country, their geological examination will follow.

Agreements have been made with the Thüringian governments, according to which their dominions also are being now taken up in this survey in the same manner.

Of the special maps there are at present 52 sheets completed, partly in print and partly in manuscript.

The experience gained in this connection has shown that the scale

upon which they are executed not only suffices to give a representation entering into the most accurate scientific details of the most complicated stratification even, but also that the picture given in the maps shows a limitation of the strata and kind of soil corresponding perfectly to reality, and thereby becomes a trustworthy guide for all purposes of practical life—for mining, quarrying, agriculture, and management of forests, public works, &c.

In this very beginning it has appeared that even in the outlines which the general maps give, corrections are requisite.

This can be understood from the fact that the conception and the representation of geological phenomena are generally subject to alterations in consequence of the advancement of science and of new discoveries.

In this respect the geological state survey is a continuous problem, the solution of which cannot in any time arrive at a final conclusion. Besides this the main reason for the difference between the total views (*gesammt bilder*) and the existing general maps (*uebersichts-karten*) lies in the different treatment itself.

The latter have for the greater part had their origin so that different districts have been surveyed independently of each other, and at different times, either through the initiative of individual observers or on the instigation of the mining authorities, whose interests are engaged in the first place.

Besides there mostly was a lack of sufficient assistance for the local observations, also of time, as in a short space of time extensive areas had to be represented, so that often dissimilar material had to be put together in the general maps.

In addition, they were not treated according to similar (uniform) scientific views, nor was the technical execution the same.

NECESSITY FOR THE FOUNDATION OF A GEOLOGICAL STATE INSTITUTE.

The proper road to avoid these drawbacks has again been first entered upon by England with the best success by placing all the operations for the geological survey of the country under the management of a special central office, the Geological Survey, founded in 1835, as stated above.

This was determined upon in consequence of the conviction that the adherence to a plan of operations for the surveys, beginning at the most prominent points, and then progressing systematically, and with a uniform conception and representation of what has been observed according to the actual state of science could not be effected in a different manner, and that the ways and means to introduce the scientific results in a beneficial manner into practical life also could, by proper combinations, be the most easily found from such a source.

It has been mentioned above that several other countries have followed the example of England.

Prussia cannot delay longer giving a solid organization to the geological state survey, if the problems still to be overcome are to be solved correctly and early, the great importance of which for the economic interests and its great extent have been shown in the preceding.

ORGANIZATION OF THE INSTITUTE.

The next question in organizing a geological state institute is to determine whether it is to be an independent institute, or whether it is to be united with a similar institution.

To arrive at a conclusion on this subject it is useful to have reference to those two institutions, which, existing a long time, have an acknowledged reputation, viz, those of England and Austria.

THE GEOLOGICAL SURVEY.

The "geological survey of the United Kingdom," in London, soon after its foundation was so organized that the highest establishment for instruction in mining, the Royal School of Mines, was united with it.

They received a common management and a common building. As, third, the Museum of Practical Geology, with a chemical laboratory, was added, a collection which consists mainly of two principal groups.

The first group is designated as that of the natural materials. It contains the collection for the geological maps, stones, petrifactions, &c.; the useful stones, building and mortar materials, marble, roofing-slate, &c., besides the other useful minerals, coal, ores, &c., occurring in the kingdom.

The second group, the artificial productions, contains a rich technological collection, illustrating in a very complete manner the use (*verarbeitung*) of the minerals of the first group in all branches of industry, especially in the metallurgical, ceramical, and chemical technics.

Other branches of the museum contain mechanical models of the mining and smelting-works technics and some historical material.

The collection is arranged in the most practical manner to satisfy every interest by which the public, in the most multifarious directions, is connected with it.

Finally, the Mining-Record Office—*i. e.*, the statistical bureau for mining—is also united with the institute.

Accordingly, the English institute has such an organization that it expresses the intimate connection between the science of geology and mining, as also education in mining, the most important bases of which are the mineralogical sciences and the whole technological industry of the raw products.

By the admission of the Mining-Record Office into the institute the relationship between the development of mining and the geological pursuits is also pointed out.

DIE K. K. GEOLOGISCHE REICHS ANSTALT.

It differs from the "K. K. Geological State Institute." It is neither in any connection with the mining authorities, nor with a mining academy, nor with the university, nor with the mineral cabinet, but is completely isolated.

Temporarily the attempt has been made to take a number of the young men studying for the state mining-service annually to assist at the geological state institute. This combination was given up again very soon, however.

This institute is connected with a museum. The latter, however, is of an exclusively geognostic, paleontological, and mineralogical nature, and its contents are, in consequence, strictly scientific, but in this exclusive direction exceedingly rich.

ORGANIZATION FOR PRUSSIA.

If for the geological institute to be founded in Berlin one of these two foreign institutes should be chosen as model, it cannot be doubtful that

the plan of organization carried through in the geological survey is by far preferable.

Evidently, the intimate connection between science and practical life which is attained there insures it the best success.

That this is so is felt in Austria also, and for some time efforts have been made to gain the natural connection of geological work and mining by instituting a mining academy in Vienna, in close union with the K. K. Geological State Institute.

CONNECTION WITH THE ACADEMY OF MINES IN BERLIN.

The elements of an organization, similar to the English one, for a geological state institute, to be erected in Prussia, are given more completely than was the case at the time of founding the Geological Survey in London.

The work of the geological state survey, which is being systematically carried out in the manner described above, belongs here to the department of the administration of mines.

The Academy of Mines already existing in Berlin is in a certain relation to the geological state survey in so far as the collections belonging to the latter are scantily accommodated in the building of the Academy of mines, as several of the geologists of the state survey are charged with lecturing at the academy, and as the director of the academy of mines is referee for the geological stat survey in the mining department of the royal ministry of commerce.

A collection corresponding in part, and as a beginning to the museum of practical geology, is contained in the museum for mining and metallurgy, which is preliminarily accommodated on the premises of the royal iron-foundry.

The different parts require only to be completely united, being at the same time perfected and enlarged in order to form an organization answering its purpose in every respect.

ADVANTAGES OF THIS UNION.

The advantages of this union are evident.

Both institutions, the Academy of Mines and the Geological State Institute, have to a great extent similar wants.

The minerological and geological collections of the Mining Academy, of a more systematic scientific nature, are of great advantage as material for study and comparison to the state survey.

The topographical geological collections forming themselves during the state survey from the proof-specimens of verification (*als Belagsuiten*) will, on the other hand, serve as an excellent means of instruction for the mining academy.

The same obtains with the collection of maps and books.

The ministerial mining library in the mining academy, one of the most complete geological and technical professional libraries, is of great value to the state survey.

The laboratories of the Mining Academy can easily be made serviceable for the various examinations necessary for the geological state survey.

Next to the advantages of the use in common of the numerous objects qualified therefor stand those which are consequent upon the working together of the persons to be employed in the two institutions.

In this respect, it is impossible to lay sufficient stress on the favorable influence exercised on the education of the students of the Mining

Academy, whether they are preparing for the state service or for private industry, when the teachers of the mineralogical sciences, by participating in the labors of the state examination, are accurately acquainted with the results and let them exercise a direct and fresh influence on their lectures.

It is therefore of the greatest value that the assistants of the state survey are also employed at the academy.

The order and superintendence of the mutual collections can be assigned to them.

On the other hand, this combination is very useful for the assistants themselves, not only in consequence of the contact with the mining interests which are represented in the academy of mines, but also on account of the impulse toward a more comprehensive scientific perfection given by the lectures which they have to deliver.

And then such a mutual activity of the fellow-workers and the mutual application of the required assistants, as draughtsmen, office-employés, and inspectors, will admit of a saving in expenses.

The utility of the union of the museum for mining and metallurgy and the geological state institute and the mining academy needs no further demonstration.

It is sufficient to point out its value as a means of instruction and as a completion of the total representation of the products of the soil of the country and of the industry depending thereon.

For the reasons represented in the preceding, it has been determined to found on the 1st of January next a Geological State Institute, in organic union with the Academy of Mines in Berlin, and thus to create an institute essentially similar to the geological survey.

Its objects have been explained previously. In regard to the execution, the following may be mentioned:

NECESSITY OF ERECTING A BUILDING FOR THE GEOLOGICAL STATE SURVEY AND THE ACADEMY OF MINES.

The importance of the subject for economic interests makes it necessary that the results obtained by the geological examinations be made accessible in the most general manner possible.

The specimens collected during the surveys for the geological maps, and the latter themselves, must therefore be publicly exhibited.

For such an exhibition and for the mere accommodation and examination of the material collected by numerous observers in the whole state considerable room is requisite, which in a proper form can be obtained only by means of a new building, for which an exigency exists, which is the more inevitable as the mining academy and the museum for mining and metallurgy cannot remain where they are at present.

The former, temporarily accommodated in the old exchange, is not able to permanently satisfy the requirements of instruction and means of education, since enlargements in the building cannot be made, and the building, even, will have to be torn down in consequence of the projects for the pleasure-garden and its surroundings.

The museum for mining and metallurgy will also have to be moved before long, as the premises of the royal iron-foundery will without a doubt find different application.

For the combined institute a new common building has therefore been planned.

HAUCHECORNE,
Oberbergrath.

Translated by F. W. Lehnartz.

§ 4. INTRODUCTORY REMARKS ON THE GEOLOGICAL SPECIAL MAP OF PRUSSIA AND THE THÜRINGIAN STATES.

The geological map of Prussia and the Thuringian states, of which the first 6 sheets have been published, is intended to be a special map in the real meaning of the word.

The topographical basis for the same is the fundamental map-work of the Prussian staff, the so-called plane-table sheets, whose scale of $\frac{1}{25000}$ is so large that all the information gained can be completely and accurately located, and the geognostical boundaries represented with an accuracy that will make them correspond exactly to reality.

The method of equidistant horizontal curves, applied to represent the relief at a vertical distance of 25 feet, drawn so that every 100-foot curve was a little heavier, in order to facilitate a more ready review, makes it possible to accurately locate and read off the real heights of all points, and, in comparison with the representation of the relief by means of hatching, it offers the advantage of greater distinctness of the whole topography as well as of the geological limitation.

For the geological work the whole topography of the original surveys of the staff is retained, so that the maps in this form are the most accurate special maps existing in point of topography.

The extent of this map-work will be very considerable. It will, first of all, cover the mountainous part of Prussia and of the Thuringian states, the governments of which have acceded in the most accommodating manner to the working-plan, so that it will extend in the south to the boundaries of Prussia and of the North-German Confederation as far as they are formed by the boundaries of the Thuringian states.

Within that extent those districts will be geologically surveyed first, for which new maps of the staff, representing the ground by means of equidistant horizontal curves, exist.

This is at present the case with the province of Saxony and with the East Harz, with the formerly electoral part of Hesse, with the southern part of the Rhenish province, and with the Thuringian states.

Of the former dukedom of Nassau the plane-table sheets are at present being prepared.

After their completion the southern part of the province of Hanover will be surveyed in a similar manner.

In the measure in which similar topographical maps are completed by the staff for other parts of the state, the geological survey will gradually be extended.

At present geological surveys are being executed in the province of Saxony, in the Harz, in the Thuringian states, in Hesse, and in the Rhine province.

Assuming as a limit for the time being for the Saxon-Thuringian group toward the north the parallel of the north border of the Harz at Vienenburg, toward the east more or less the thirtieth degree of longitude, which is not quite reached near Halle and at the Saxon frontier, but crossed by the territory of Saxony, Altenburg approximately just as much, then the Saxon-Thuringian group consists of 268 plane-table sections, each of which contains an area of $2\frac{1}{4}$ square miles.

The former electoral Hessian territory contains 112 sections, Nassau will contain 55 sections, the southern part of the Rhine province about 110 sections, the former Hanoverian territory between the Harz and Hesse about 30 sections, so that there are here all in all 575 sections in immediate connection with each other to be surveyed.

The organization of the geological surveys is at present arranged in the following manner:

Within the territory, which is to be first begun, the surveys are executed in groups, which connect partly with the special preparatory work done formerly and partly correspond to the places of residence of the assisting geologists, so that the separate groups will gradually close, to become a whole. Such working-districts are at present as follows:

1. The Harz is being surveyed by Prof. Dr. Beyrich and Dr. Lossen. The 6 sheets published with this number, which contain the Lower Permian conglomerate and sandstone, together with the Plutonic formation (*Eruptiv gesteine*) of the district of Ihlefeld and the sublying older Hercynian strata, and a part of the belt of magnesian limestone (*Zechslein*) inclosing the Harz, belong to this group.

The sheets in question will be followed, from this part of the work, by the sheets connecting with the former in the east and extending over the older Hercynian formation of the East Harz.

2. The Thuringian Triassic basin. (*Triasbecken*,) closing with the Harz in the south, is being surveyed by Dr. Eck, Prof. V. Seebach, and Berg assessor Giebelhausen, beginning with the Ohm Mountain and its surroundings, between Nordhausen and Göttingen.

Farther east the nearly-finished special survey of the Kyffhäuser by Prof. Dr. Beyrich, will join.

3. The porphyry and the Lower Permian formation (*Rothliegende*) conglomerate, and the Carboniferous, as also the diluvial formation of the district of Halle, have been examined by Dr. Laspeyres.

The surveys are being continued by Assessor Giebelhausen, as Dr. Laspeyres has been called to the polytechnic school at Aachen.

4. The south Thuringian Triassic of the district of Jena, Weimar, and Erfurt is being examined anew by Prof. Dr. Schmid, of Jena, who will also survey a part of the inner Thuringian forest.

5. The Lower Permian formation and a part of the Plutonic formation (*Eruptiv gesteine*) of the West Thuringian forest are being surveyed by Prof. Dr. Roth.

6. Joining these sections in the west Dr. Mösta, together with Prof. Dr. Beyrich, surveys the Permian limestone (*Zechstein*) and Triassic formations of the Werra valley, beginning in the neighborhood of Eschwege and Sontra.

7. The surveys of the Zechstein formations of the southern border of the Thuringian forest and of the Trias of the upper Werra valley are being executed by Prof. Dr. Emmrich, of Meiningen, beginning in the sections Meiningen, Salzungen, Dorndorf, and the surrounding sections.

8. Beginning at Saalfeld, Director Dr. Richter is preparing a map of the slate-formation (*Schiefergebirge*) of Thuringia and of the adjoining more recent formations.

9. The section of Prof. Dr. Liebe in Gera will join to the former in the east.

10. Dr. Weiss, finally, is executing under the special direction of Dr. V. Dechen, the survey of the Carboniferous formation of Saarbrücken.

As soon as the plane-table sheets of Nassau are printed, the preparation of the geological special map will be begun.

In order to insure uniformity in the scientific conception and the graphical representation, so many assistants taking part in the extensive work, one of the co-laborers, Prof. Dr. Beyrich, of Berlin, has been charged with the scientific direction of the geological survey and mapping of the Prussian states, and, by the agreements made with the

Thuringian states, a uniform (similar) treatment of the contributions furnished by them for the mutual undertaking has been secured.

All the finished maps, or those ready to be published, of the different assistants, are delivered by the same to the directory of the geological state survey in Berlin, which consists of Prof. Dr. Beyrich and the referree for these matters in the department of mines of the royal ministry of commerce, trade, and directory of the public works, at present Bergrath Hauchecorne, director of the Academy of Mines.

This central bureau effects the final editing, and after the edited sheets have been sent to their authors for a last revision and obtained their assent to the final review, the publication is printed. Of course, every one of the numbers when it appears bears the name of the respective observer.

At a meeting of the assistants, which takes place every year at the general conference of the German Geological Society, the work which has been done is presented and discussed.

The offices of the directory of the geological state survey are in the Academy of Mines in Berlin.

As vouchers for the geological maps a comprehensive collection of the stones, petrifactions, and minerals gathered during the surveys is formed here, which will become, as it enlarges, a geological state museum, for which an organization as a public institute has been planned.

Heretofore this collection has been restricted to Prussian territory.

Besides, there have been fitted up at the Academy of Mines, for the purposes of the geological state survey, a draughtsman's office and a chemical office in the academical laboratory, standing under the direction of Prof. Dr. Finkener, for the examination of the collected stones, minerals, and useful fossils.

The finished maps will be published in numbers, which, like the present one, consist of several contiguous sheets, and will contain, as far as possible, a complete geognostical district.

After the present number there will very soon follow 12 sheets on the district of Jena, by Prof. Dr. Schmid; 6 sheets on the Ohm Mountain and the district of Bleicherode, by Dr. Eck, Prof. von Seebach, and Assessor Giebelhausen; 3 sheets on the district of Halle, by Dr. Laspeyres; and 6 sheets on the formerly electoral Hessian Triassic and Permian region of the district of Eschwege, by Dr. Mösta and Prof. Dr. Beyrich.

There are also nearly completed 6 sheets containing the Kyffhäuser Mountain, 4 sheets on the East Harz, uniting with the sheets now published the sections Saalfeld and Meiningen, and the first 6 sheets of the southern part of the Carboniferous formation of Saarbrücken.

For several other sections work has been executed which is far less advanced.

With this state of the preparatory work, the publication can take place in quick succession.

The sale of the maps, which has been intrusted to Neumann's map-establishment, will take place so that every section will be sold singly for the low price of 20 silbergroschen, so that, in accord with the character of the work, a special map, not only the scientific interest of the professional student but also particularly the local interests of the farmer, the forester, the miner, and of technics generally, may be satisfied as much as possible.

For the solution of this problem, it appeared advisable to add an independent short text to every sheet, which gives the explanations necessary for the general understanding of the established geognostical conventional signs.

This explanatory text will, in this connection, not discuss any scientific controversy, nor give literary references, but will confine itself to pointing out in as comprehensive a manner as possible the local peculiarities of every sheet.

In this manner numerous repetitions in the explanations for contiguous sheets cannot be avoided, even though in the more explicit remarks in regard to separate geognostical circumstances in the text for one section that of a neighboring section will be frequently referred to, in which the respective occurrences appear to be especially developed.

Besides these short explanations, full descriptions will be published of larger adjoining districts, and dissertations on specially important observations will be published in the form of essays, as far as there may be material for such.

In regard to the position of the separate sections in each number, a sketch of part of the total map-territory on the binding of the number will give the necessary information, showing the plane-table sections, according to the general net of the staff, with the number of each section and of the group to which it belongs, and where the sections concerned are made prominent by hatching.

May the great and difficult work begun herewith furnish a great many new discoveries (*Bausteine*) to geological science.

May it at the same time approach its second object as much as possible, to gain numerous new friends for the examination of the soil of our country and to make this knowledge the common property of all.

BEYRICH HAUCHECORNE.

Berlin, July, 1870.

Translated by F. W. Lehnartz.

§ 5. INSTRUCTIONS FOR THE ROYAL STATE GEOLOGISTS.

1. The royal state geologists have to perform their services according to the instructions and under the supervision of the directory of the Geological State Institute.

2. *Sphere of business.*—The services of the royal state geologists consist of—

(1) The local surveys for the geological maps which are published by the Geological State Institute.

(2) The preparation of the geological maps for the examined districts.

(3) The preparation of the explanatory text for these maps.

(4) The scientific work on the petrographical, palæontological, and mineralogical material collected during the surveys.

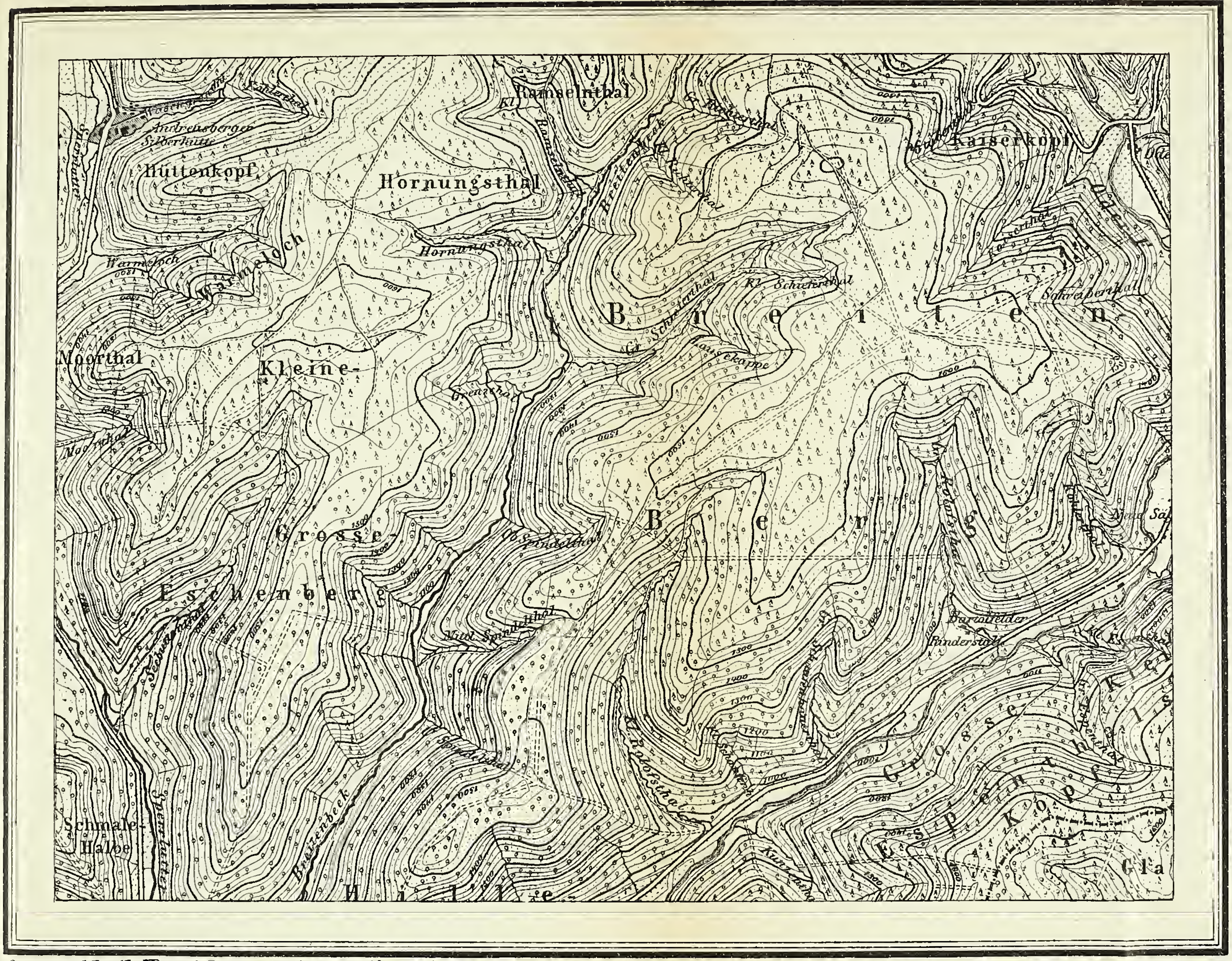
Besides, the state geologists have to obey any special orders from the royal ministry of commerce or the directory of the Geological State Institute in regard to the state survey and the respective collections.

3. The state geologists living in Berlin have to assist as lecturers on the mineralogical sciences at the Academy of Mines, and to perform the work on the parts of the collections of the Geological State Institute which may be assigned to them. They will receive definite instructions, in regard to the lectures and the work in the collections, from the directory.

4. *Surveys.*—The territory to be surveyed each year by the state geologists is determined by the directory, according to the plan of the work and the state of execution at the time being.

As a rule, the whole summer-semestre, or at least five months of the same, is to be employed for the survey.

A different use of a part of this time, for such scientific purposes as



Surveyed by the Royal Prussian Gen. Staff in 1858

Scale 1:25000

Contours $2\frac{1}{2}$ Ruthen or 25 Dec. Feet apart

½° 1° 2° 3° 4° 5° 10° 15° 20° 30° 45°

Note

A Ruthe = 12.35667 Eng. Ft. Decimal Foot = $\frac{1}{10}$ Ruthe = 1.235667 Eng. Feet

do not come within the scope of the work of the Geological State Institute, can be made only after special approval of the directory.

5. *Mapping.*—The results of the survey have to be drawn into the respective sheets of the map, and must be made into geological representations completely colored, so that when the whole extent of a map-section is completed it can be turned in ready for publication. Even if the whole extent of the section is not surveyed, but only one part of the same, that part must be nevertheless filled in with formation-limits and geological coloring.

Particular (*Aufschlusspunkt*) maps are to be drawn only of those districts which the directory has specially indicated.

6. *Explanations.*—For the geologically-surveyed sections explanations must be written.

For the completed sheets they must be brought into such a form that they can be published as text for the same.

For the sheets that are only partially worked out explanatory reports must be prepared in a similar manner.

Besides the material for the text, notes must be taken, during the survey of everything that may be of interest, for the geological archive, *e. g.*, boring-records, existing geological preparatory work, profiles, &c.

7. The executed maps and explanatory reports, as well as the other mentioned notes, must be delivered to the directory in the course of the month of December of the working year, and certainly previous to the 1st of January of the following year, in a complete form, according to the above directions, sub. 4 and 5, together with a short letter of transmittal and a liquidation of the traveling-expenses.

The maps, whether they be entirely or only partly completed, must be handed in clean, drawn on uncut sheets, the explanations in clean copy. They are not returned to the authors, but are destined for the archives.

8. *Verifying collections.*—Verifying collections of a petrographical, palæontological, and mineralogical nature are to be made for the districts under survey, destined for the geological state museum.

In this connection, however, only such occurrences are to be noticed as are of a special scientific or collection interest and have a characteristic proof-importance for the respective locality.

A size of about $7\frac{1}{2}$ to $10\frac{1}{4}$ centimeters is to be given to the mineralogical specimens.

If within the section under survey, local collections having reference to the same are found, the acquisition of which for the geological State museum appears to be desirable, they may be bought for it by the state geologists without further notice, if the price does not exceed 25 thalers. Should the price be higher, the sanction of the directory will be necessary.

To develop particular deposits, laborers' wages may be paid, also, however, not to exceed 25 thalers in one surveying period, without special sanction of the directory.

Original receipts must be taken for purchases, as well as all other expenditures for labor, packing, transportation, &c., and presented for settlement at the same time as the traveling-expense liquidation.

9. The principle must be adhered to that all the scientific material collected during the survey is the property of the geological state museum. Upon special instruction of the directory, duplicates for scientific provincial institutes, universities, &c., may be picked out and transmitted by the directory.

10. *Preparation and delivery of the collections.*—The objects collecte

during the surveys must be arranged during the winter succeeding the time of the survey, and provided with labels according to the rules of the state museum, and delivered to the directory for admittance into the museum.

11. *Liquidation of traveling-expenses.*—The liquidation accompanying the report on the work done and to be handed in in the course of December must show the number of days employed on the surveys and the cash-expenditures, the latter, as mentioned above, with original vouchers.

After the liquidation an advance may be given out of the (*oberberghauptmannschaftlichen*) contingent fund upon special application. The application must be made to the directory.

The above instructions are herewith approved.

Berlin, August 13, 1873.

The Minister of Commerce, Trade, and Public Works,

Dr. ACHENBACH.

Translated by F. W. Lehnartz.

CHAPTER IV.

§ 1. MEMOIR ON AUSTRIAN SURVEYS.

The K. K. (Austrian) Military Geographical Institute is charged with the survey of the whole empire, and of the production and publication of the maps based on the same, and also of the production and multiplication of the maps, plans, and drawings necessary for the use of the army, with a view to as great general usefulness as possible, and with the application of the method of representation which is the best suited for the purpose at the present time; it also has to furnish geographical and topographical aid for other branches of the administration and for private enterprises, as far as can be done with the force and means of the institute to meet such special requirements without injury to its proper object. In war-times the institute has to provide the commanders and staffs of the armies and army corps with maps. Accordingly its work naturally consists of three parts: the trigonometrical triangulation, together with the respective astronomic-geodetical operations, the production of the field-sheets, and the drawing of maps, which have to take place in this order in the work of the institute.

It is an army-institute, under the war-department, through the chief of staff, and is directed by a general. All the members of the same consist partly of officers, military officials, and the technical assisting force, non-commissioned officers; then, for the lower services, of soldiers, and also, as occasion may demand, of workmen engaged by agreement. It is a rule that officers are employed for the scientific and field wo k, (triangulation and map production;) for the purely technical work, however, officials, although this rule is subject to modifications.

The officers and officials of the institute draw a fixed salary, advance in rank and salary according to their categories, when vacancies occur, and, in case of their being disabled for service, they are entitled to a pension. The vacancies occurring in the lowest grades of the technical officials in consequence of such promotions are filled from the ranks of the army or from the contract-workmen, for whose engagement from civil life the directory of the institute is authorized, according to require-

ment and disposable funds, for a compensation fixed by agreement The candidates for such places must be healthy, and must have passed for this purpose a technical examination with good result, after which their appointments, upon the recommendation of the directory of the institute, are made by the war department.

The institute consists at present of the following departments:

1. Adjutant's department.
2. Military triangulation.
3. Military-map production.
4. I. Group consisting of—

    a, topographical department.
    b, lithography.
    c, copper-engraving.
    d, topographical school.

5. II. Group consisting of—

    a, presses, book-binding.
    b, galvanoplastics.
    c, photography, photolithography, and heliogravure.

6. Map correction and revision.
7. Archives and library.
8. Consumption of maps.
9. Commission of administration and account-office.
10. Non-commissioned officers' department.

1. ADJUTANT'S DEPARTMENT.

This consists of one captain as chief, who is aided by a second officer for assistance in his work and by six non-commissioned officers to do the current writing and forward the manuscripts and maps.

It receives all the manuscripts sent from outside or from the departments to the directory of the institute, where they are recorded and referred to the respective departmental chiefs, or to the directory of the institute. Besides, the adjutant's department keeps a record of all personal matters, and of all papers bearing on the relations of position and service, and disposes of the same in the proper manner.

The number of official documents annually amounts at present to about 34,000. The number of those official documents sent out annually from the directory to the different departments of the institute amounts to about 13,000; 4,000 official letters and about 2,000 packages or rolls with maps for the city; 10,000 official letters and 13,000 packages or rolls with maps, and 1,000 money-packages, with about 400,000 fl. ö. w., sent out of the city, (*nach auswärts.*)

2. MILITARY TRIANGULATION.

This department consists of 1 higher staff officer as director, 1 staff officer as representative, 8 captains, 14 first lieutenants, 6 lieutenants, and 3 non-commissioned officers as observers and computers.

For the field-work these individuals are formed into parties of 2 to 3 officers, (1 trigonometer and 1 to 2 assistants; for base-measuring generally, 4 to 5 officers,) and each party is assigned to a special field of work.

The military triangulation is charged with the execution of the trigonometrical field-work and computation as bases for the succeeding

graphical military state survey and for the cadaster,* as also in part for the scientific purposes of the European *Gradmessung*, which is now in progress. The latter falls within the extent of the monarchy in its astronomical part in charge of the commission of surveyors and astronomers, appointed by the K. K. administration, and to which the director of the triangulation also belongs, under whose special direction the geodetical work of the *Gradmessung* is executed, that falls to the care of the institute. Two officers of the triangulation-division have been assigned to that *Gradmessung's* commission as assistants and computers.

The other work of the triangulation-division consists of the execution and computation of a net of triangles of the first and second order, covering the whole monarchy, together with the necessary measuring of bases, determinations of latitudes and azimuths at points selected for that purpose in this net of triangles, and in the formation and computation of an interpolated net of triangles of the third order for the use of the state survey, the angle-points being determined in a horizontal as well as in a vertical sense.† It consists furthermore of the computation of the geographical positions and polar co-ordinates of the angle-points; the precision-levels, executed with specially-constructed leveling-instruments for the European *Gradmessung*, astronomical determinations of positions, and measurements of heights by means of aneroids in neighboring countries which have not yet been surveyed, together with descriptions of routes and of military reconnaissances; the computation and construction of the new sheets for the degree-map,‡ and the special maps of Austria-Hungary; the computation of the rectangular co-ordinates of all the corner-points of the military sections necessary for the production of the field-sheets, so that the outlines of the survey-sections can be given according to degrees and constructed; the compilation and publication of the astronomic-geodetical work, executed for the purposes of the European *Gradmessung*, as well as the levels and the remaining triangulations. To execute these works the triangulation-directory has at its disposal the following instruments:

One fixed transit-telescope, with straight telescope of $1^{m}.32$ focal distance and 79^{mm} aperture of object-glass;

One large universal-instrument, with broken telescope, with 53^{mm} objective aperture, and 60 and 90 fold magnifying power; horizontal, as well as vertical, limb has 34^{cm} diameter, and two microscopes, permitting the reading of 1 second and the estimation of fractions of the same;

One large universal-instrument, with broken telescope of 46^{mm} objective aperture, magnifying 60 and 90 times; the azimuth-limb has $31^{cm}.6$, the vertical limb $26^{cm}.3$ diameter; each has two microscopes, admitting of directly reading off 1 second and estimating fractions of the same;

One large universal-instrument, with telescope in the axis, objective aperture 46^{mm}, magnifying 40 and 60 times. The 2 limbs have diam-

* This is a department of the finance-ministry which conducts the cadastral triangulation, and the state survey of the cadaster, based thereon, on the scale of $\frac{1}{2500}$, for the purpose of determining the ground-tax, not paying attention to irregularities of the ground.

† For the extent of the former, now abolished, military boundary, (*Militärgrenze,*) the triangulation and computation bureau of the institute had also to fix a net of triangles of the third and fourth order for the works of the cadaster.

‡ Every whole sheet of the degree-map comprises 15 minutes geographical latitude and 30 minutes geographical longitude, by the meridians and parallels of which it is bounded in the form of a trapezoid, and contains 4 military survey-sections. It is drawn on the scale of $\frac{1}{75000}$, and is provided at the ends of the borders with numbers which indicate the longitudes and latitudes of the border-lines.

eters of $26^{cm}.3$, and have each 2 microscopes, with direct reading of 1 second;

One small universal instrument, with broken telescope; limbs of $13^{cm}.2$ diameter, with 2 verniers, giving a direct reading of 10 seconds;

One small universal instrument, with broken telescope. Both circles have diameters of $10^{cm}.5$, with 2 verniers reading to 20 seconds;

One small universal-instrument, with telescope in the axis. The 2 circles have diameters of $7^{cm}.9$ and 2 microscopes, giving a direct reading of 5 seconds;

Two large portable transit-instruments, with broken telescopes of 66^{mm} objective opening, magnifying 60, 90, and 120 times; one has a striding, the other a hanging level;

One small portable transit-instrument, with broken telescope 46^{mm} objective opening, and striding level;

Five theodolites of new construction; telescope can be reversed; horizontal circle has 26^{cm}, vertical-circle 21^{cm} diameter; both movable, and each with 2 microscopes giving a direct reading of 1 second;

Two theodolites of equal construction as the previous ones; horizontal circle with diameter of 21^{cm}, and vertical circle with diameter of 20^{cm};

One repeating theodolite of old construction, horizontal circle 31^{cm}, with 2 microscopes and direct reading to 1 second; the fixed vertical-circle has 22^{cm}, with 2 verniers, giving a direct reading of 10 seconds;

Two repeating theodolites of similar construction as the previous one, but the horizontal limb has $26^{cm}.3$, and the vertical-limb 20^{cm} diameter.

With the exception of the fixed transit-telescope, all the previously-mentioned instruments are from the mechanical establishment of G. Starke, at Vienna.

One repeating theodolite, of Ertel, in Munich, horizontal circle 25^{cm}, vertical circle 19^{cm} diameter, each with 2 microscopes and direct reading to 1 second;

One repeating circle, by Borda, of about 40^{cm} diameter, not used since the year 1859; and

One old non-repeating theodolite, by Reichenbach, with horizontal circle of 21^{cm} diameter, and vernier reading, not used for a long time;

Two Gauss's heliotropes;

Four Starke's heliotropes;

Thirteen Bessel-Baeyer heliotropes;

Two Steinheil's heliotropes;

One base-measuring apparatus, after Delambre, contains 4 iron rods, each 2 toises long, 1 plumbing arrangement, and a leveling-instrument, &c.;

Eight leveling-instruments for precise levels, by G. Starke;

One astronomical clock, by Molyneux, with mercury compensation;

One astronomical clock, with gridiron compensation;

Eight traveling chronometers;

One standard mercurial barometer, after Fortin and Gay-Lussac, by Kapeller;

Aneroids and thermometers in great number, likewise scales, measuring-tapes, &c.;

One magnetic theodolite;

One inclinatorium;

Two pyrheliometers;

A special observatory in the building of the institute for practicing in the use of the instruments and in observing.

3. MILITARY-TOPOGRAPHICAL DEPARTMENT, (MAP-PRODUCING DEPARTMENT.)

It consists of 1 higher staff-officer as director; then of 16 topographic divisions, each of which consists of 1 staff-officer or captain as subdirector, 8 officers as topographers, and 1 non-commissioned officer as clerk. Every subdirector, or topographer, has assigned to him for the time of the field-work 2 soldiers, (in case of need 3 or 4,) as laborers.

The military-topographical direction supervises also the military drawing and pantograph divisions, the first of which consists of 20 to 24 officers, and the latter of 10 officers and 20 non-commissioned officers, and both are superintended by a staff-officer as representative of the topographical director.

The object of the military-drawing division is, in the first place, to further educate officers of the army who have a sufficient elementary knowledge in drawing and mathematics in those branches of science which are necessary for carrying on the military survey. Those branches are, lower geodesy, topographical drawing, knowledge of the earth's surface, tactics, besides exercise in the use of surveying-instruments and in the necessary height-computations. Here also corrections are made in the original sheets, for example, in the case of streets, railroads, &c., according to newly-obtained data, newly-measured heights and lines of equal altitude are drawn in, and modeling work according to relief-drawings is prepared. To assist in their better education the pupils hear daily lectures delivered by the staff-officer representing the topographical director, and at the close of the year they must assist in a six weeks' survey for practice.

The object of the pantography is, to prepare graphically, on the scale of the survey, the section-borders, or the borders of the survey-sheets, according to the computed degree-map sheets; to reduce into the same the cadastral maps drawn, without relief, on the tenfold scale of the military-survey sections, to the scale of the survey; to draw, in a preparatory manner only, the roads, towns, cultivations, &c.; partly to color them after the trigonometrical points have been carefully plotted by means of rectangular co-ordinates; then to prepare the parish boundaries and descriptions.

The work of the military-topographical department consists of the graphical survey of the country, and the military description of the same, namely, in regard to the first, in regions where there are no cadastral surveys in existence as yet, it consists of a completely new survey, and where cadastral surveys have already been made, in a survey on the basis of the pantographically-reduced cadastre-maps; in both cases determining numerous elevations by means of special height-determining instruments.

All the state surveys are plotted on the scale of 1:25,000, except in particular cases—for instance, large cities and their surroundings, manoeuvring and camping grounds, &c., which are drawn on the double scale, $\frac{1}{12500}$ within such borders as the arrangement of the map, according to degrees on the one hand, and the size of the sheet on the other, demand, in quarter-degree map-sheets. Where cadrastral surveys do not exist, and where, in consequence, such cannot be used as bases for the state survey, the topographical department receives the distances of certain fixed points, determined by means of astronomo-trigonometrical operations, and computed by the triangulation-division, together with their elevations, to such an extent that every quarter-degree map-sheet usually contains three, or in the worst case at least two, such fixed points,

with one or two (even if beyond the border of the sheet, yet close to the same) third or third and fourth ones, all being well situated and intervisible. Such a quarter-degree map-sheet, denoted as northwest, northeast, southwest, southeast section of the respective degree-map sheet, is fastened on the plane-table, and the survey completely executed on the same on the basis of the trigonometrically-determined points, which have been plotted on the sheet, beginning with a triangulation with stations determined by the topographer himself, (*nach selbst-gewählten Punkten.*)

When the cadastre-surveys, executed on the larger scale, can be used as bases for the military state survey, then the degree-map sheets are planned according to the survey-scale, the skeleton contained in the cadastre-sheets is, by means of the pantograph, carefully reduced and drawn into the same, making use of the carefully-plotted trigonometrical points, and these reductions, drawn in pencil, distributed among the topographers in section-quarters. Accordingly the graphical triangulation of the topographer becomes unnecessary, in so far as it will be required exceptionally only, for the determinations in the horizontal net, when extensive corrections are shown to be necessary. Special points, the absolute heights of which it has been found necessary to determine, are, however, in this case, also established by triangulation. The topographer has, therefore, in reality, only to make a revision (*Reambulirung*) of the skeleton, changed since the cadastre survey, and to plot the ground-irregularities at sight, together with the height-determinations; during the winter-months, however, the complete draughting of the summer's survey has to be executed.

The basis for the height-determinations is given by the results computed by the triangulation-department. Based on the trigonometrically-determined points of elevation, the topographical subdirector, within the limits of his division, determines with his universal instrument, for every topographer, such a number of well-controlled points that he may be enabled to interpolate any number of new points of height. With the universal instrument zenith-distances are measured, from which the differences of height are computed. The horizontal distances needed for this purpose are either computed from the triangle observed with the universal instrument, or are carefully taken from the sheet with the dividers. Every topographer is provided with a small instrument for measuring heights, with which he can, like the subdirector, determine and compute the required differences of elevation. Besides this, the topographer has good aneroid barometers by Naudet at his disposal, for measuring heights in woody regions. In this manner, there are, on an average, at least eight well-distributed heights determined per square kilometer, which the topographer makes use of, in order, during the winter, to plot lines of equal elevation, 100 meters apart vertically in one manner, and 20 meters apart vertically in another manner, in red brown color, on the basis of these measured heights and of the lines of greatest inclination that had been judged of by sight and sketched on the ground. The execution of this work is the summer occupation of the topographer, which period extends from May 1 to the end of October.

Each topographical division remains during the winter in one of the principal towns of its district, or of the district assigned to it for the following year, where, in November, it begins the winter-work, which consists of the construction of the contour-lines and the complete clean-drawing in color, according to the adopted conventional signs (*nach dem bestehenden Situations-Zeichnungsschlüssel*) of the country surveyed during the summer; the hachure of the irregularities is done in

black, according to the established shade-scale in the manner of Lehmann.

An experienced topographer can survey during the summer months, according to his aptitude and to the nature of the ground, on an average, from 350 to 500 square kilometers, with about eight height-determinations per square kilometer; on the double scale about 150 to 230 square kilometers, with about 17 heights per square kilometer; compute the measured heights, and plot the same in winter.

It is the duty of the topographical director to conduct and superintend the uniform execution of the survey, strictly in accordance with the existing instructions, subject to the deciding influence of the directory of the institute, for which purpose he inspects all the divisions during the summer, and carefully examines the elaborate maps of the topographers, already revised by the subdirectors and forwarded to the directory of the institute at the close of the winter, and reports upon the same to the directory of the institute. He is, moreover, charged with the appropriate distribution of the districts to be surveyed, to the subdirectors, the direction of the officers' drawing-school, and the pantography.

I GROUP.

This is charged with the reduction of the military surveys to the scale of the maps, the preparation of the drawings required for the heliography, as well as all other map-drawings, and the direct (*unmüttelbare*) engraving of maps on stone and on copper, and finally the correction of the heliographically prepared plates. This consists of 1 higher staff-officer as chief of group, 1 staff-officer as chief of the topographical division, 2 officials with analogous rank, as chiefs of the divisions of lithography and of copper-engraving, and one captain as chief of the topographical school, together with the requisite assistance.

a. Topographical division.—Sixty individuals, partly officers, partly officials, partly non-commissioned officers, are employed in the same. Its office is, to furnish drawings so that they, according to their purpose, may serve either as hand-drawings or for the different manners of reproduction, as heliography, lithography, copper-print, photography, photo-lithography, &c.

b. Lithography.—Here the stone-plates are completely prepared for the print, on the basis of direct or photolithographically prepared tracings, (*pausen*,) in the various kinds of lithography, either engraved, or in autographic ink, or in chalk, &c. This division is conducted by a technical superior official, under whom are lower officials and non-commissioned officers.

c. Copper-engraving.—In this division, which is also conducted by a technical superior official, 24 officials and non-commissioned officers are employed. They have to make the corrections in the copper-plates prepared heliographically, engrave the graduation (*gradirung*) and the scales, and make the required corrections in the lettering and in the skeleton. Besides that, they have to make the additions and corrections in the copper-plates prescribed by the revision and the correction.

d. Topographical school.—In this there are at present occupied 75 officers or non-commissioned officers under direction of a captain, part of whom are now occupied in the drawing of the skeleton, and the other part with the representation of the irregularities of the ground for the new special map of Austria-Hungary. Its object is to develop draughtsmen competent to furnish drawings which are perfectly fitted for heliogravure, and who will in future independently execute such drawings themselves. Drawings from which a good heliogravure shall be obtained

must be drawn with quite black ink and sharp edges. The paper must not have suffered any noticeable damage in consequence of erasures. Draughtsmen who work for the heliogravures must, therefore, be particularly well schooled.

Of the state survey on the scale of 1:25,000, where four survey-sections form one degree map-sheet, a copy on the scale of 1 : 60,000 is prepared for the topographical draughtsmen, who use the same to draw the special map-sheet on the same scale, and thoroughly in black. This original drawing, executed on a whole undivided sheet, is photographically reduced to the special-map scale of 1 : 75,000, and of this photograph the heliographical copper-plate is made. On an average, it may be assumed that by an experienced draughtsman one degree map-sheet in 1 : 60,000, quite black, will be finished in ten months. In the execution, however, the lettering and horizontal net is made by one and the drawing of the relief by another draughtsman.

II GROUP.

This is charged with the technical reproduction of the maps and with the execution of all the trials (*Versuche*) and other technical operations in that respect. It consists of one higher technical official as chief of the group, and 2 subordinate technical superior officials as chiefs of divisions, and of the required number of officials and other technical assistants and non-commissioned officers for the manipulations.

a. Presses and book-binding.—This division is under a technical superior official, who is its chief, and employs 100 persons, who are partly steadily employed (have a fixed appointment) and partly employed by contract. Two steam (*schnell*) and hand presses are busy almost without interruption, with which there are produced annually 625,000 prints, of which the lithographic prints are proportioned to the copper prints as 11 to 1.

b. Galvano-plastic.—This is under a subofficial as master, directly under the chief of the group, and occupies 22 individuals, who are partly on a fixed salary, and partly non-commissioned officers assigned to this work. It has to cover the heliographically-produced copper-plates with a thin layer of steel, for the purpose of making it more durable in case of need to multiply the same, and to galvanically fill out with copper those parts of the completed copper-plates within which alterations or corrections occur, so that in those places the requisite additions and corrections can be made by the copper-engraver. In the course of one year there are about 600 high and low relief plates of different sizes prepared here.

c. Photography.—This division is charged with the multiplication of the topographical surveys, drawings, and other similar originals (*Vorlagen*) by making extended use of—

Silver-photography, (when the want of copies of the military-survey sections is limited;)

Photography in printers' ink or coal, (to make permanent copies of the survey sections for special purposes;)

Photolithography, (for the reproduction of such maps and plans, mostly surroundings, (*Umgebungspläne*,) which are not subject to a correction, and must be made ready in the shortest possible time;)

Heliogravure*, (for maps which are intended for continuous use and must be kept corrected.)

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* By this process, which is still a state secret, a copper-plate is within six weeks obtained directly from the black drawing, so that it is ready for the print with the copper-printing press. The first work produced by heliography is the general map of Central Europe, which is prepared by the print of two plates, (one for the skeleton, the other for the ground, terrain.) For the saving of time and expense, it is reprinted on stone for publication.

Besides these, in rare cases use is made of coal-photography and chromolithography. The kind of reproduction is dependent also on the state of the original and the requirements to be made of the same. Under the direction of a superior official there are annually produced by 40 officials and non-commissioned officers about 1,700 photographical glass-negatives for copies on paper, partly for transfers on stone, copper, and zinc; nearly 5,700 photographical silver copies, for immediate want; 1,500 degree-map sections as unchangeable photography in coal, for use of the army in the field; nearly 100 photographic copies (*pausen*) on stone, for lithographic engraving, and nearly 240 heliographic plates for the special map.

6. MAP CORRECTION AND REVISION.

A special correcting office in charge of a staff-officer attends to the addition of all changes in the railroads, as also in new or altered roads, &c., which they have to add to the original survey-sections, as also to the original map-drawings, and then turns over the corrections made to the lithographic and copper-engraving division for correcting the stones and plates. The corrected prints are again sent back to the correcting office for approval or renewed correction. Two officers and four technical officials are employed here. For the revision of the original drawings of the special map there are employed, in addition, five officers to revise the maps drawn in the topographical division, especially with reference to the correct application of the conventional signs and of nomenclature, previous to their transfer to the reproducing division.

7. ARCHIVES AND LIBRARY.

This division is charged with the acquisition, collection, and deposition of all new book and map works of interest in this connection, (*einschlägig;*) also, with the delivery of the same to the different divisions for reference, (*Dienst-gebranch;*) with the exchange of home publications with those of foreign states; the acquisition, testing, and delivery of the instruments for triangulation and topography; with the testing of the aneroids coming into use, and the preparation of the respective tables of corrections; the presentation of the results of the examination of new instruments and apparatus; the compilation of the annual reports on the work done by the institute. It consists of one staff-officer as chief, two officers, two non-commissioned officers, and one army servant.

8. CONSUMPTION OF MAPS.

Besides the different book and art establishments home and foreign, which are charged with the disposal of the maps produced by the Institute, the Institute has a depot of its own in the city, where the maps can be obtained by everybody. This depot is in charge of a captain, who has one non-commissioned officer and one servant for the manipulations assigned to him.

9. MANAGEMENT AND ACCOUNT OFFICE.

The cash-account (*Cassa-Geschäft*) and the management are conducted by commissions specially formed for this purpose from the employés (*Personalstande*) of the Institute. Each of the commissions is composed of three members, viz: the cash-commission, of the director of the Institute as president, and two staff-officers; the commission of manage-

K. K. MILITARY GEOGRAPHICAL INSTITUTE.

Statement showing the rank and the pay of the persons employed in the different divisions, together with the extraordinary expenses.

Divisions.	Persons, salaries, and extraordinary expenses and payments under contract.	Extraordinary expenses and payments of contracts.	From the etat of the K. K. army. Generals, staff-officers, and officers: General major.	Colonels.	Majors.	Captains: 1st class.	Captains: 2d class.	1st lieutenants.	Lieutenants.	Captain accountants.	Lieutenant accountants.	Men: Non-commissioned officers and soldiers.	Men: Officers' servants.	Total.	Technical officers: Chiefs of groups.	Chiefs: 1st class.	Chiefs: 2d class.	Officials: 1st class.	Officials: 2d class.	Officials: 3d class.	Assistants.	Technical assistants: Masters: 1st class.	Masters: 2d class.	Assistants: 1st class.	Assistants: 2d class.	Army servants: 1st class.	Army servants: 2d class.	Army servants: 3d class.	Laborers under contract, from civil life.	Total.	Total sum.
Direction of the institute	Number of persons		1											1												1				1	2
	Salaries		6,483											6,483												702				702	7,185
	Extraordinary expenses and payments under contract																														
Adjutant's office	Number of persons					1	1					6	2	10													1			1	11
	Salaries					1,644	1,344					1,215	257	4,460													582			582	5,042
	Extraordinary expenses and payments under contract	2,200																													2,200
Military triangulation	Number of persons			1	1	6	2	14	4			34	28	90												1				1	91
	Salaries			3,778	2,278	9,864	2,688	14,070	3,540			6,868	3,571	46,657												702				702	47,359
	Extraordinary expenses and payments under contract	13,200																													13,200
Military topography: Surveying divisions	Number of persons				4	14	17	58	52			304	145	594																	594
	Salaries				9,112	23,016	22,848	58,290	46,024			61,636	18,632	239,558																	239,558
	Extraordinary expenses and payments under contract	168,000																													168,000
Military topography: Pantographic division	Number of persons						2	3				20	5	30																	30
	Salaries						2,688	3,015				4,041	642	10,386																	10,386
	Extraordinary expenses and payments under contract	10,000																													10,000
Military topography: Drawing division	Number of persons				1	1		5	10				17	34														1		1	35
	Salaries				2,278	1,644		5,025	8,850				2,145	19,942														522		522	20,464
	Extraordinary expenses and payments under contract	3,200																													3,200
Group I: Chief of group	Number of persons			1									1	2													1			1	3
	Salaries			3,778									128	3,906													582			582	4,488
	Extraordinary expenses and payments under contract																														
Group I: Topographical division	Number of persons			1				5	4			15	10	35				10	6	4	3					1			10	34	69
	Salaries			3,778				5,025	3,540			3,038	1,285	16,666				16,368	8,020	3,988	2,631					702			400	32,109	48,775
	Extraordinary expenses and payments under contract	18,000																													18,000
Group I: Lithographic division	Number of persons											5		5			1	2	2	3	3					1			2	14	19
	Salaries											1,012		1,012			2,270	3,273	2,673	2,991	2,631					702			80	14,620	15,632
	Extraordinary expenses and payments under contract	2,700																													2,700
Group I: Copper-engraving division	Number of persons											1		1			1	6	7	2	3							1	2	22	23
	Salaries											203		203			2,270	9,819	9,357	1,994	2,631							522	80	26,673	26,876
	Extraordinary expenses and payments under contract	9,000																													9,000
Group I: Topographic school	Number of persons					2	1	22	28				53	106							5					1		3	12	21	127
	Salaries					3,288	1,344	22,110	24,780				6,813	58,335							4,386					702		1,566	480	7,134	65,469
	Extraordinary expenses and payments under contract	33,713																													33,713
Group II: Chief of group	Number of persons														1												1			2	2
	Salaries														3,770												582			4,352	4,352
	Extraordinary expenses and payments under contract	400																													400
Group II: Printing division and book-bindery	Number of persons											37		37		1						2		20			1		40	64	101
	Salaries											7,494		7,494		2,690						1,525		11,655			582			16,452	23,946
	Extraordinary expenses and payments under contract	17,500																													17,500
Group II: Galvano-plastics	Number of persons											1		1								2			20					22	23
	Salaries											203		203								1,525			10,455					11,980	12,183
	Extraordinary expenses and payments under contract	1,000																													1,000
Group II: Photographic division	Number of persons					1						14	1	16			1	1	3	7	5		1	4	4		1	1		28	44
	Salaries					1,644						2,835	129	4,608			2,270	1,636	4,010	6,980	4,386		666	2,331	2,091		582	522		25,474	30,082
	Extraordinary expenses and payments under contract	8,000																													8,000
Map correction and revision office	Number of persons				1	7	2	2				1	12	25					1	2	1									4	29
	Salaries				2,278	11,508	2,688	2,010				203	1,542	20,229					1,336	1,994	877									4,207	24,436
	Extraordinary expenses and payments under contract	2,000																													2,000
Archives and library	Number of persons				1		1	1				2	3	8														1		1	9
	Salaries				2,278		1,344	1,005				405	385	5,417														522		522	5,939
	Extraordinary expenses and payments under contract	500																													500
Non-commissioned officers' division	Number of persons					1						24	1	26																	26
	Salaries					1,644						4,861	129	6,634																	6,634
	Extraordinary expenses and payments under contract	3,500																													3,500
Account office	Number of persons									1	2	6	3	12													1		2	3	15
	Salaries									1,644	1,770	1,216	385	5,015													582		80	662	5,677
	Extraordinary expenses and payments under contract	2,000																													2,000
Map consumption	Number of persons					1						2	1	4												1				1	5
	Salaries					1,644						404	129	2,177												702				702	2,879
	Extraordinary expenses and payments under contract	300																													300
Totals	Number of persons		1	3	8	34	26	110	98	1	2	472	282	1,037	1	1	3	19	19	18	20	4	1	24	24	6	6	7	68	221	1,258
	Dues	295,213	6,483	11,334	18,224	55,896	34,944	110,550	86,734	1,644	1,770	95,634	36,172	459,385	3,770	2,690	6,810	31,096	25,396	17,917	17,542	3,050	666	13,986	12,546	4,212	3,492	3,654	1,120	147,977	902,575

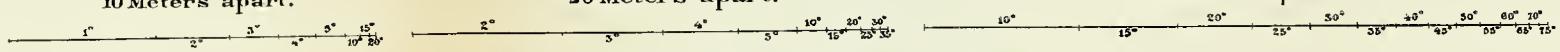
NOTE.—The dues are paid in guilders, O. W., (Austrian valuta.)

AUSTRIAN SCALES FOR CONTOUR LINES AND HACHURES.

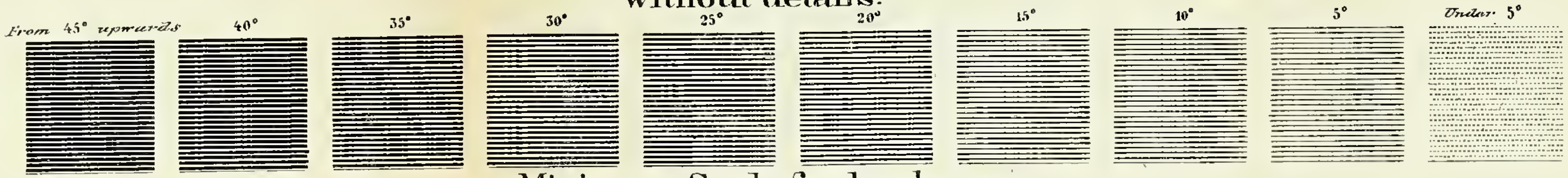
Sheet VI.

Horizontal distances between Contour lines.

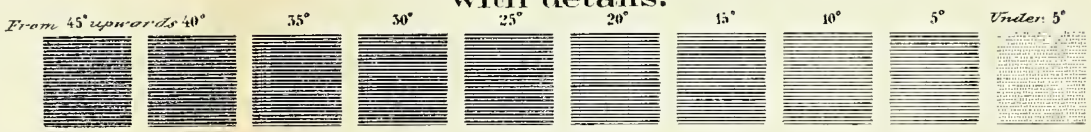
Scale, 1:25000.



Maximum Scale for hachures without details.



Minimum Scale for hachures with details.



Example.

Showing the use of the Scales.

Principal	Contour lines	— — — —	100	Meters	apart.
Intermediate	" "	————	20	"	"
Auxiliary	" "	----------	10	"	"

Scale, 1:25000.

ment, of a staff-officer as president; besides, of a captain and the director of the account-office.

The latter is the economic-administrative adviser of the director of the Institute as well as of the commission of management.

The cash-commission is charged with the disposition of the money in gross; and to conduct the cash-business in the daily and small affairs, a cashier's office is set apart, which is superintended by a captain.

The commission of management is charged, subject to the approval of the director of the Institute, with providing the Institute with all requisites, as money, materials, &c., and with the sale of the products of the Institute.

The account-office, subject to special instructions in regard to accounts and to demeanor, (*Gebehrung*,) performs the service of book-keeping, in a mercantile sense, and is therefore also to be looked upon, together with the office for state property, as an economic-administrative executive organ of the director of the Institute and of the commission of management.

It consists of a captain-account-keeper as director of the office, of two lieutenants-account-keepers, six accounts-assistants, and three clerks.

10. NON-COMMISSIONED OFFICERS' DIVISION.

Similar to the officers' drawing division, there also exists a division composed of forty well-behaved and sufficiently advanced non-commissioned officers or soldiers of the K. K. army, in charge of a captain, who are here instructed in lettering and the representation of the ground and relief, and prepared for their future employment in different divisions of the Institute.

Concerning the representation of the objects, the key to the conventional signs (*Situations-Zeichnungs-Schlüssel*) adopted for the topographical divisions is added in the appendix, and the further explanations of the manner of representation of the published maps is shown on each of them.

In regard to the samples of maps, it is further remarked that every year in July, the newest products of the Institute are sent through the K. K. Imperial War Department and the K. K. Ministry of the Exterior to the Smithsonian Institute in Washington.

The salaries (*Personal Dezüge*) of the persons employed in the different divisions of the Institute, and the expenditure of materials, are shown in the annexed statements.

K. K. GEOGRAPHICAL INSTITUTE.

Statement showing the amount of money expended in one year for writing and drawing materials, chemicals, paper, and instruments, &c., and of the expenditures for management and other purposes:

	Amounts in Austrian currency.	
	Fl.	*Kr.*
In the Institute itself	69, 000	....
For the triangulation	20, 600	....
For the production of maps	34, 500	....
Total	124, 100	....

Authority.—A manuscript memoir furnished by the Austrian government. (Translated by F. W. Lehnartz.)

CHAPTER V.

§ Notes on Italian Geodetic and Topographic Surveys.

CHARTOGRAPHY FROM 1815 TO 1861.

In this period of considerable length we have few copies of real Italian topographical works to be proud of. The principal maps of the Italian territory belong to Austria, which certainly was interested in having a detailed and correct topographical chart of Italy. But if Austria initiated it in the more important works of Italy, and in the greater part of the best publications, it is not less true that the greater part of this merit is due to their scientists, who belonged to the flourishing "Deposito di Guerra" of Milan, re-organized when the Austrians took possession of Lombardo-Venetia as the "Istitute Geografico," and remained in the metropolis of Lombardy till the year 1839, after which it was transferred to Vienna, and enlarged, became that famous Geographical Institute so well known, in which Italian artists were always employed.

Still, the other states of Italy did not remain idle; some very precious work came to light, and more could have been done by Piedmont and Naples if the political events had not disturbed the minds and aims of all from the quiet work of science and art. However, hereafter we will enumerate what has been done on the Italian soil, not only from our initiative, but from the Austrian.

A. *Kingdom of Sardinia.*—Piedmont was not without topographical elements, but they were not published. They were gathered before the French revolution by the topographical body existing then. Probably they were the manuscripts used for the composition of a new edition of the map of Borgonio.

During the period of the French domination and of the fighting of that era, the topographical works were suspended entirely; the Senate and Government retired to the isle of Sardinia.

In that period of time some copies were executed by the French and Austrian officers, but they naturally remained in their hands.

Suddenly, after the return to Turin of the House of Savoy in 1815, the continuation of a general map of the kingdom was ordered. And though the work for the grand triangulation was not resumed, yet they began the topographical survey. The two Riviere, the Canavese, the Monferrato, the county of Nizza were surveyed, part with the plane-table and part with the compass. Afterward they found themselves without means, and thought of using the cadastral maps for all the other provinces where the tax-maps existed.

Those cadastral maps, reduced to the same scale and carefully inserted in the trigonometrical nets that were in progress, were examined and completed on the ground, but in the elevated region of the mountains those documents were also defective, and for them there is not correct topographical material, but only the results of a reconnaissance without instruments.

The work proceeded with assiduity and correctness, so that by the end of 1830 all the provinces of the country were run through, and the trigonometric nets extended all over its soil. Then they commenced the formation of the projected map on the scale of $\frac{1}{50000}$. This had to be composed of 94 sheets. The copies were drawn, in water-colors, in the office of the staff, and the number of sheets was reduced to 91. The publication of so extensive an atlas lasted several years. In the mean

time the army and the public administrations were left without a correct official topographical map, not being able to consider as such that of the royal engineer, Giuseppe Momo, constructed and published with old elements in 1819 on the scale of about $\frac{1}{284750}$. This map had too little detail, though well delineated and well printed. Therefore they thought of forming, by means of deductions from the data gathered, a chorographical map, on a scale of $\frac{1}{250000}$. The project was carried out, and between 1841 and 1851 the beautiful map of $\frac{1}{250000}$, in six sheets, engraved on copper, appeared. It is a very valuable document, notwithstanding the high mountains were not based upon correct data.

The topographical maps of $\frac{1}{50000}$ were then successively published, but by a simple lithographical method, in consequence of the lack of artists and the urgent demand for such documents. This publication began in 1851 and continued till 1870. The sheets, before being published, were corrected on the ground.

During this long period some other works and publications were carried on and completed. We will enumerate several of these topographical works.

In 1835 a survey on the $\frac{1}{10000}$ scale was undertaken of the maritime Alps, employing the pretorian plane-table and the stadia telescope. The elevations were represented by horizontal curves. This work was continued for several years, till they accomplished the survey of all the county of Nizza. But, on account of lack of means, an order interposed in 1851 and suspended that work, as it was excessively expensive.

In the years 1854, 1855, and 1856 were made some surveys, on the scale of $\frac{1}{10000}$, in the vicinity of Fenestrelle, for the purpose of giving practice to the scholars of the staff-school. And in the year 1857–'58, with the same idea, and on the same scale, was executed the survey of a part of the high valley of the Stura.

In 1857 the survey of the territory between Casale, Alessandria, and Stradella was also begun on the scale of $\frac{1}{10000}$. This work was not all published.

With the same publications there is a chorographical map of the isle of Sardinia that has some merit. It is in two sheets, engraved on copper, and on the scale of $\frac{1}{250000}$. This beautiful map, based on a trigonometrical net, departing from two bases, measured—one at Cagliari, the other at Oristano—is the work of a private individual, General Alberto La Marmora, of whom we have already spoken. The map was given to the public in 1845, and it is the only existing one of any value of that island.

Among the publications of less value we will mention the beautiful map of the country surrounding Racconigi, comprising one sheet, engraved on copper, on the scale of $\frac{1}{50000}$, and the map of the territory of Saint Maurizio, also on copper, of one sheet, and on the scale of $\frac{1}{15000}$, and published in 1864.

B. *Lombardo-Venetia.*—One of the first maps published by the Geographical Institute of Milan was that of Milan and the surrounding country, on the scale of $\frac{1}{50000}$ engraved on copper, in four sheets. After this the military map was commenced, with a change of scale and system of representing the ground, on the scale of $\frac{1}{86400}$, (not with the meter as a unit, but with the Klafter of Vienna.) This was, and is today, a model of precision and of careful execution. The map was to comprehend Venetia-Lombardy, but was extended to the duchies of Parma and Modena, and, at last, to Tuscany, Lucca, and the Pontifical States, (Central Italy.) It was made in separate sheets, that could be united, as they were all of the same scale and the same geodetic execu-

tion. The topography consisted of cadastral maps, reduced to the scale of $\frac{1}{28800}$, which harmonized with the maps based on military triangulation, which were rectified and completed on the ground. Then they were drawn again, being reduced to the scale of $\frac{1}{86400}$, and given to the engravers on copper, who produced those magnificent maps which are to-day admired by all who are versed in topography.

These maps have the following dates of publication:

1828—Map of the duchy of Parma, Piacenza, and Guastalla, in 9 sheets, on copper.

1833—Map of Venetia-Lombardy, in 42 sheets, on copper.

1839—Map of the duchy of Modena, in 9 sheets, on copper.

1851—Map of Central Italy, in 52 sheets, engraved on stone.

The first three were executed in Milan and the fourth in Vienna.

Another work of great importance was published in Milan through the exertions of this same institute. This was the atlas of the Adriatic Sea, designed and engraved on copper in the Military Geographical Institute of Milan, (begun in 1817 and finished in 1830.) This is a general hydrographical map, in two sheets, on the scale of $\frac{1}{500000}$, and also of thirty sheets of details, on the scale of $\frac{1}{175000}$, and with a collection of 100 views of the principal seaports. To the above-mentioned atlas was annexed a descriptive portion, with the following title: "Pilot for the Adriatic Sea, compiled under the direction of the Military Geographical Institute and of the I. R. general staff, by Captain Giacomo Marieni."

The Neapolitan officers co-operated in the maritime survey for the formation of this grand work for the Adriatic coast of the kingdom of Naples. This publication was received by the public as a prodigy of science and art.

C. *Duchies of Parma, Piacenza, and Guastalla.*—We have no originals to make mention of except the completion of the tax-maps in 1836 by the government of Maria Louisa.

D. *Duchy of Modena.*—The officers of Modena took part with the Austrians, not only in the triangulation but also in the topographical survey of the ground.

E. *Grand-Duchy of Tuscany.*—The cadastral survey of Tuscany began in 1819 and was completed in 1827, based upon the beautiful triangulation of the professor, Père Inghirami.

These cadastral maps served Père Inghirami as elements for the construction of a beautiful chorographical map of the Grand-Duchy, on the scale of $\frac{1}{200000}$. The maps were reduced and completed on the ground.

The map, based on geodetic nets of the author, and adorned with various indications, was engraved on copper, in four sheets, and published in 1830. The execution is admirable, and can compete with those of the Geographical Institute of Milan. This is the only original map that has been published by the Grand-Duchy of Tuscany in the present century.

F. *Pontifical States.*—The only original work of importance was the tax-map, on the scale of $\frac{1}{2000}$, finished in 1821.

We may also add the map of Rome and adjacent country, constructed and published upon geodetic work, by the engineers Conti and Calandrelli, of whom we have already spoken.

G. *Kingdom of the Two Sicilies.*—From the geodetic work above mentioned, we see that science, in spite of the many interruptions caused by political events, was not neglected in Naples.

Here we will note also that topography and the art of engraving

were cultivated with particular care by the Neapolitan Topographical Office.

The topographical works and publications were numerous, but, for the most part, partial. Perhaps the means and circumstances prevented the completion of large works; perhaps, also, a sufficient impulse was wanting.

The project of a map of the kingdom, on the scale of $\frac{1}{80000}$, reduced from that of $\frac{1}{20000}$, was magnificent, but it was only commenced, and they were obliged to satisfy themselves with a general map, on the $\frac{1}{640000}$-scale, of the kingdom this side of the Faro, and with a map of Sicily, on the scale of $\frac{1}{260000}$, in four sheets.

The execution of the first sheets on the $\frac{1}{80000}$-scale was accomplished very accurately, scientifically, and splendidly by the skill of the designers and engravers; it is a sin that such a work was not completed.

In praise of the Topographical Office, which was the first and oldest institute of this kind established in Italy, we will enumerate some of the best works accomplished in this second part of the Italian topography:

First. The map of the provinces of Naples and a portion of the provinces of Caserta and Avellino, in fifteen sheets, engraved on copper, and on the scale of $\frac{1}{25000}$, commenced in 1819. This beautiful work of publication ought to have been extended to the kingdom of Naples; but the plan was changed, and a partial map was constructed for the above-mentioned regions, suspending further works.

Second. The plan of the city of Naples and the surrounding country, in one sheet, engraved on copper, on the scale of $\frac{1}{7675}$, published in 1828.

Third. The plan of the city and port of Trapani, in one sheet, engraved on copper, on the scale of $\frac{1}{7500}$, published in 1839.

Fourth. The plan of the city of Palermo and surrounding country, in four sheets, engraved on copper, on the scale of $\frac{1}{5000}$, and that in one sheet on the scale of $\frac{1}{9110}$, published in 1818.

Fifth. The plan of the city and Strait of Messina, in one sheet, on copper, on the scale of $\frac{1}{30000}$, published in 1832.

Sixth. Map of the shore of the river Tronto to the Cape Saint Maria di Leuca; atlas in thirteen sheets, engraved on copper, scale $\frac{1}{100000}$, published in 1834.

Also, many maps of maritime cities and foreign sea-ports.

ITALIAN CARTOGRAPHY FROM 1860 TO 1875.

GEODETIC WORKS.

At the beginning of the new kingdom of Italy the need of a general topographical map was felt, on a scale large enough to serve with profit to the army, and to be used by the administration of the kingdom and by private individuals. The proportion of 1 to 50,000 seemed the most appropriate, except for interesting regions, where, for one reason or another, it was necessary to use a larger scale.

We have already seen, in the progress of this article, what general topographical maps existed in the single states of which Italy was composed, so that we do not need to enumerate them again.

Nevertheless, we will sum them up:

1st. The map of the provinces of the kingdom of Sardinia, on the scale of $\frac{1}{50000}$, in progress of publication, and the reduced one, on the scale of $\frac{1}{250000}$.

2d. The map of the isle of Sardinia, on the scale of $\frac{1}{250000}$.

3d. The Austrian maps, on the scale of $\frac{1}{86400}$, of Venetia-Lombardy, the duchies of Parma and Modena, and Central Italy.

4th. The map of Tuscany, by Inghirami, on the scale of $\frac{1}{200000}$.

5th. The map of the kingdom of Naples, by Rizzi Zannoni, on the scale of $\frac{1}{114942}$.

6th. The map of the isle of Sicily, on the scale of $\frac{1}{260000}$.

All these maps, except the first, were more or less ancient, of different scales, and such as did not satisfy all requirements. All were drawn with system and conventional signs, but they were not uniform. None were made on a regular plan throughout. Whilst, therefore, the maps numbered 1, 2, 3, and 4 represent clearly enough the details of the land, especially those of Piedmont and Austria, those numbered 5 and 6 were not completed, and were not susceptible of improvement. They were maps truly valuable for the epoch in which they were made; but the system of representation and the geodetic inaccuracy did not admit of correction.

In this state of things the Italian government decided to construct, first, a map of the Neapolitan provinces, and of the isle of Sicily; and a project for this purpose was presented to the parliament in 1861.

The geodetic work was begun in the same year in Sicily, basing the triangulation on the existing one in the province of Palermo. They had not time to measure a base, because they wished to furnish, as quickly as possible, the trigonometrical points to the topographers charged with the survey of the ground, reserving the correction of the primary triangulation until after the measurement of one or two bases which was to be made before ending the geodetic operations.

The instruments employed were repeating theodolites of Gambey and Ertel. The calculation was according to the formula of Puissant; the allowable error being $\pm$ 5″ for triangles and $\frac{1}{15000}$ for distances.

While every one was proceeding to the execution of these works, an event happened which modified the adopted project, substituting more precise methods for observation and calculation.

General Baeyer, the dean of those versed in geodesy, proposed in 1861 to the Prussian government to invite the European governments to form an association for the purpose of undertaking in common the measurement of a portion of an arc of a meridian and of a parallel on a central zone of the European continent.

The Italian government and most of the states accepted the invitation of Prussia. Italy sent delegates to the convention, which assembled at Berlin between the 15th and 22d of October, 1864.

We will not insist on mentioning the agreements of the conference relative to the conditions which determined the operation destined to accomplish the scientific aim proposed. The agreements and reasons which dictated it are minutely described in the exact reports published at the end of each meeting of the conference. We shall limit ourselves to noting the new direction that this event gave to the Italian geodetic works.

The Italian commission met at Turin in June, 1865, and adopted the following resolutions:

The geodetic nets, for the measurement of the European degrees, will be three, and will spread along the lines of three meridians and of three parallels.

The directions selected were as follows:

(*a*) The first net will extend from Cagliari by the island of Corsica along the Tuscan shore to Genoa and Milan, extending across Switzerland, Western Germany, to Christiana.

(*b*) The second, starting from the island of Ponza, will be carried, by Rome, Florence, and Padua, to Munich, Leipsic, and Berlin.

(*c*) The third from Cape Passaro, the extreme southeast of Sicily, by Messina, Potenza, Foggia, and the island of Tremiti, will cross the Adriatic Sea and extend in Dalmatia to connect with the Austrian nets, stretching by Vienna and Prague to the Baltic Sea.

The three nets along the parallel circle are the following:

(*d*) The first from the frontier of Savoy, extending to Padua, following the middle parallel already mentioned, from Bordeaux to Fiume.

(*e*) The second will commence in Corsica, extend to Gargano, and pass to the Dalmatian shore.

(*f*) Third, from the island of Ponza to Brindisi.

The practicability of connecting Sicily with Africa by means of geodetic operations was considered; of remeasuring the meridional net of P. Beccaria between Mondovi and Andrate, and finally of establishing a net of triangles in the longitudinal direction of the Italian peninsula, as much for the purpose of connecting the already-mentioned nets, as for the eventual measurement of oblique arcs.

It was determined that the nets should be double, that is to say, formed by connecting polygons for the purpose of determining equations of condition for the computation of compensation.

As a matter of convenience, it was determined that, for each series of 20 to 25 triangles a base should be measured with great care, in order to serve as a check, and they were located at the following points as most suitable: Trapani, Catania, Taranto, Foggia, Rome, Rimini, Leghorn, Somma, Turin, and Cagliari.

It was proposed to employ the reiterating circle, for observation of angles, supplied with microscopes of such power as to be able to read to $1''$ or $2''$, without excluding the use of the repeating theodolite.

For the determination of heights it was decided to employ the method of reciprocal observations.

In the computation of the geodetic nets, it was decided to employ the formula of Bessel, and to use logarithmic tables of ten decimals to keep account of angles to the hundredth of a second, and of distances to the hundredth, and in the calculation of compensation to go to thousandths.

The computations had to be made by polygons composed of such a number of triangles that in the progress of the computations they would not be obliged to solve more than thirty equations. The elements of the perimeter, common to two contiguous polygons, had, besides, to satisfy conditions of geometry, taking an absolute value: (*a*) for angles, the mean of the single result given for the adjustment of the two polygons; (*b*) for the relation of the sides, in the same way, the mean value; (*c*) for the absolute length, the value deduced from two or three nearer bases, assigning, nevertheless, to each base a weight depending on its proximity and on the probable error in its measurement.

We have thought it convenient to indicate in a concise way the form above mentioned, to give an idea clear enough of the geodetic works of the first order which Italy is in the way of executing, and of the precision which is aimed at.

We shall say only a few words in regard to the astronomical works, enough to indicate their connection with the geodetic operations.

It was ordered that the places to be determined astronomically should be—

1st. The existing astronomical observatories, (there are, large and small together, about 20.)

2d. A certain number of stations at the points of conjunction of the geodetic meridian nets with the parallel.

3d. The stations or places where it has been found or it is believed there are anomalies in regard to the intensity of the force of gravity.

For such a purpose, in regard to latitude, it was decided—

(*a*) To establish observatories on the meridian of Cagliari, in one or two places on the island of Sardinia; one or two in Corsica; one in the island of Elba, at Pisa, at Genoa, at Tortona, at Pavia, at Milan, and at a point on the Swiss frontier.

(*b*) On the meridian of Ponza, observation of the latitude of Ponza, Rome, Naples, Montefiascone, Perugia, Florence, Rimini, Bologna.

(*c*) On the meridian of Cape Passaro, observation of latitude of Cape Passaro, Catania, Messina, Cosenza, Potenza, and Foggia.

(*d*) On the short meridian of Turin, considering the excessive local attraction, the latitude of San Remo will be determined, from a point to be selected on the Apennines, also the latitude of Mondovi, Sanfré, Saluzzo, Turin, Massi, Andrate.

The longitudes to be determined are—

(*e*) On the middle parallel, and in consideration of the fact that in the valley of the Po there are many local attractions, there will be determined with electric apparatus the differences of longitude between Geneva and Mont Cénis, between Mont Cénis and Turin, between Turin and Milan, between Milan and Padua. It was also thought that it would be useful to insert other determinations by means of fire-signals, and by means of chronometric expeditions.

(*f*) On the parallel Ajaccio Gargano, the differences of longitude between Ajaccio and the island of Elba, between this and Rome, and between Rome and the Gargano.

(*g*) On the parallel of Ponza-Brindisi, the differences of longitude between Ponza and Naples, between Naples and Potenza, and between Potenza and Brindisi.

It has been ordered since that the determination of azimuth ought to be made:

1st. In all astronomical observatories.

2d. At all astronomical stations situated at the intersection of the geodetic meridian nets with those of the parallels.

3d. At all places where it was thought that such a determination could throw light on the nature of local observations.

4th. At several points of Calabria and of the north shore of Sicily, on the hypothesis that the connection between Sicily and Africa would be effected.

5th. At the extreme points of the meridian arcs and of the parallels above mentioned, viz, Cagliari, Ponza, Brindisi, Cape Passaro, &c.

Together the number of points to be astronomically determined would be about 60. It was determined to connect with greater care the existing observatories and the astronomical stations of the country with the geodetic nets.

The geodetic work has been continued in Italy since 1865 on the plan indicated by the international commission. Although circumstances have allowed only a small number of operators to be employed in the field and in the computations, nevertheless a considerable part of the programme has been completed.

The arc of the meridian between Cape Passaro and Dalmatia of 6° has been observed, calculated, and adjusted; and the crossing of the Adriatic has been completed in connection with the Austrians, between the Gargano and Dalmatia, and between Terra d'Otranto and Albania.

They measured the bases of Naples, of Catania, at the mouth of the river Crati, of Lecce, and in the spring of 1873 a base near Udine was measured by the Italian and Austrian officers, each one using his own apparatus for the purpose of comparing the results obtained and the value of each apparatus.

The sheet published on the scale of $\frac{1}{3000000}$ gives a clear idea of the triangulation of the first order executed in the southern provinces of Italy.

On examining this map it can be seen that the meridian net from Cape Passaro to Dalmatia was observed and subjected to the calculation of compensation. The difference in the lines with which the triangles are covered shows the different portions into which the total net has been subdivided in order to subject it to the calculation of compensation, without having a great number of normal equations to solve.

1st. Starting from the south and going towards the north one can see the Sicilian net extending from Renna-Mezzogregorio to Santa Croce-Sant'Angelo di Patti, Sant'Angelo di Patti-Tre Fontane. This net comprises 29 triangles of 30 to 40 kilometers to the side, beside a chain of 12 triangles from the base of Catania and extending to the side of first order Monte-Rossi-Perrière.

In this first work were used partly repeating instruments; this is the cause of the mean error exceeding two or three tenths of a second.

The instruments which were used for such operations are a 10-inch Gambey theodolite, a 12-inch Reichenbach theodolite, an 8-inch Gambey theodolite, a 10-inch universal instrument of Pistor & Martins, an 8-inch universal instrument of Pistor & Martins. The first three were repeating, the last two reiterating.

It will be observed that the western part of Sicily has a net of triangles not subject to the calculations of compensation.

It is the portion of our triangulation that was executed between 1862 and 1864, resting upon the side of the old Neapolitan triangulation, the aim of which was only that of supplying data for the topographical surveys.

The high scientific purpose of measuring a terrestrial arc did not enter into the works executed before the formation of the commission.

This work, however, will soon be resumed, to make all convenient corrections, and some time it will unite Sicily to Africa by Cape Bon, which operation, as a consequence, cannot be avoided.

2d. There are to be formed the nets between Sicily and Calabria from the side of Santa Croce-Sant'Angelo di Patti, Sant'Angelo di Patti-Tre Fontane, to the side Montea-Serra Castellara, Serra Castellara-Cozzo Sordillo, Cozzo Sordillo-Capo Trionto.

This net presents 27 triangles comprised in the general compensation and three independent ones.

The mean error of each direction deduced from the compensation, is

$$0''.815 \pm 0''.045$$

The instruments which we have used are a 10-inch repeating theodolite of Gambey; reiterating theodolite of Repsold, 10-inch; Starke, 10-inch; Pistor, 10-inch; Pistor, 8-inch.

The nets mentioned present sides whose length is exceptional in our operations; these are the sides of triangles which unite Sicily to the continent, crossing the sea, touching the island of Ionia. The longest side is Stromboli-Montea; this is 120 kilometers.

In spite of the exceptional condition of this triangulation the results of its comparison with that of Sicily were very satisfactory.

The triangulation between Calabria and Sicily, supported on the base of Crati, is interesting in the harmony of the connection of the triangulation, that is of the sides Santa Croce-Sant'Angelo, Sant'Angelo-Tre-Fontane. The difference between the logarithms of these sides, given by the two triangulations does not exceed 72 units of the seventh order, which is equivalent to a small difference of $\frac{1}{60000}$ in the length of the sides.

3d. The triangulation between Calabria and Basilicata presents the following data: 25 compensating triangles, 8 triangles outside of the compensation net, 7 formed with directions already compensated and out of the nets here considered.

Mean error in all directions,

$$0''.376 \pm 0.019.$$

The instruments used were of Pistor, Repsold & Starke, each of 10-inch limb.

4th. The net of Basilicata comprises 25 triangles included in the general compensation, and 3 independent triangles. This net starts from the side of the triangulation between Calabria and Basilicata, Giagola-Alpi, Alpi-Nocara, and falls on the side of Puglia Biccari-Ascoli, Cerignola-Torre Pietre.

Mean error in all directions.

$$0''.485 \pm 0.025.$$

Instruments: Repsold and Starke, of 10-inch limb.

5th. Net between Puglia and Dalmatia. This is united to that of Basilicata by the already-mentioned sides, and crosses the Adriatic, touching the islands of Tremiti and Lissa, and unites in Dalmatia with the Austrian nets.

Number of triangles forming system of compensation, 30; and 8 independent ones.

Mean error of each direction,

$$0''.683 \pm 0''.035.$$

Instruments: Reichenbach, 12-inch, (reapeating;) Pistor, Starke and Repsold, 10-inch, (reiterating.)

The triangulations of Puglia and Basilicata are supported on the base of Foggia. They connect with the triangulation of Crati on the sides of Alpi-Bulgaria, Alpi-Nocara.

The difference is of 14 units decimals of seventh order in the logarithms of the common sides; that is to say, that the error which is to be feared on the sides does not surpass the $\frac{1}{250000}$ of their length, a result very satisfactory.

Now we think it will be very interesting to say something on the measure of the bases.

The apparatus which we used was constructed by Ertel, of Munich, on the plan of that of Bessel.

We shall not stop to consider the illustrious scientist's method of measurement, but the following figures will certainly show the high grade of precision attained by us.

1st. Base of Catania: length 1,894 toises, with a mean error of 1 line and 22 hundredths.

2d. Base of Crati: length 1,497 toises, with a mean error of one 1 line and 984 thousandths.

3d. Base of Lecce: length 1,560 toises, with a mean error of 1 line.

4th. Base of Undine: this base, whose definite value has not yet been calculated, was, as we have said before, measured in the spring of 1873 by Italian and Austrian officers with their own apparatus.

The harmony between the measurement and remeasurement of the Italians was much greater than could have been expected, and an absolute agreement has been ascertained between the Austrian and Italian results.

It is easy to understand the advantage of this comparison of measurements and the results that may be deduced for the comparison of the triangulation of the two states and for the equalization of their measurements.

This would be the place to speak of the results obtained in the operation of geodetic leveling, which was spoken of in the conference of 1864. But this category of operations has since received new direction by the Swiss scientists Hirsch and Plantamour, and the importance of geometrical levelings of precision has been recognized.

Italy intends to undertake as much as possible for the benefit of the works which place her in correlation with the countries which took the precedence in such operations.

We shall yet observe that the trigonometrical net on the parallel Brindisi-Ponza is almost entirely observed and will soon be also calculated; that five astronomical stations have been finished by determination of latitude and azimuth, that is to say, those of Naples, Monte Mario, Termoli, Lecce and Potenza; that they have telegraphically determined the difference of longitude between Palermo, Naples, and Rome; between Milan, Simplon, and Neufchatel; between Milan, Padua, Genoa, and Naples.

All the geodetical and astronomical work, done with the aim of measuring terrestrial arcs, will form the subject of scientific publications; and there are now in progress of publication several accounts concerning our measure of bases, and the determination of difference of longitude of Milan, of Simplon, and Neufchatel. That of the observations on latitude and azimuth at Lecce exist already.

Already, by the diligence of the observatory of Naples, reasons and results of analogous operations made between the observatories of Rome, Naples, and Palermo have been published.

At the same time that they were working to execute the grand net for the measure of the European degree, the works to determine the trigonometrical nets were actuated by the aim to furnish the necessary bases to the geographers.

It was ordered to determine a trigonometric point for each 25 square kilometers.

The geodetic work has been continued and will still be carried on for some years, in connection with the astronomical measure of the degree in Europe, and the results, in view of the precision with which they have been carried on up to this time, cannot be less splendid.

In the current geodetic campaign (1875) operations are being carried on in the Tuscan and Ligurian Appenines, and various astronomical stations are being occupied, which pertain to the measure of a degree in Middle and Lower Italy.

TOPOGRAPHICAL WORKS AND PUBLISHED MAPS.

The unity of Italy has been of great benefit to the national topography and cartography. The Italian Staff took all the topographical elements scattered in the different states of Italy, superintending them all except that of Naples, which was preserved as a section of the superior office, and thence of the technical office of the staff of the army, because, possessing an observatory, good geodetic instruments, able operators and

artists, under a sky so favorable to observations, it could bring, as in fact it did, usefulness and dignity to science and art. This is the period of the true Italian National Cartography.

Soon after the first annexations of 1859, the government felt the need of a general map of all the provinces of Middle and High Italy recently annexed; and as the time was short, it was thought best to take the existing materials, in order to compile it quicker. Therefore the well-known cartographic map was issued, on the scale of $\frac{1}{600000}$, of Upper and Central Italy, in 6 sheets, engraved on copper, and finished in 1864. For the first 4 sheets were used the plates of the chorographic map of the Alps, together with the work "Le Alpi che cingono l'Italia." For the fifth sheet they made the most of the map of the island of Sardinia, by General Alberto La Marmora; and for the sixth, a reduction of the corresponding part of the Austrian map, on the scale of $\frac{1}{86400}$, was made. They were at first on copper plates, and in reductions the principal variations found in topography and in the systems of roads and hydraulics of the countries were represented.

We have previously stated how, after the annexation of Naples and Sicily, it was of supreme necessity to give as soon as possible to the army and to the administration a map of the southern provinces of Italy and Sicily.

It was not possible to wait for the completion of the beautiful Neapolitan map, on the scale of $\frac{1}{80000}$, which was being engraved on copper in the Topographical Office of Naples; and those existing of Rizzi-Zannoni and of the island of Sicily (this last compiled from the works of Captain Smyth, of the English navy) were too old and were based on geodetic elements rather incorrect, although for artistic execution they could be called admirable for the time in which they were published.

Soon after the beginning of the geodetic work of which we spoke in the previous chapter, the topographers went to work in Sicily and took the plan of the ground. The scale chosen was that of $\frac{1}{50000}$, a bold innovation, which, nevertheless, in fact, succeeded very well. The survey was made with a plane-table and perfected telescope, which did not leave anything to be wished. All the graphical points of our field-work were determined by intersection or by the stadia, and were plotted, an operation which has rendered very easy the tracing with precision the equidistant horizontal curves for every 10 meters elevation.

The survey of the isle of Sicily, commenced in 1862, was finished in 1868.

Field sketches neatly copied in the office could be reproduced. They were in fact reproduced by photography and the heliotype process, and became valuable to those who required such. They truly represented the exact drawing of the ground, and the engineers, engravers, and technical men found in them elements necessary for a new process.

The need of the state and the continual advancement of every man that becomes known inspires scientific genius, artistical and mechanical. It was truly the exigencies of the epoch and of the land, in which and for which he lived, that inspired Colonel Avet, of the Staff Corps; he discovered by profound and continuous study a wonderful process of reproduction, viz, photoincision.

It was wished to give immediately to the scientific world a great proof of this process of reproduction, and the map of Sicily was reproduced in the brief period of two years, reducing it to the scale of $\frac{1}{100000}$ in 48 sheets, and reducing it from the originals of $\frac{1}{50000}$, neatly copied. We have possessed it since 1871.

Hardly were the topographical works of the island finished, when they

passed to the survey of the Neapolitan provinces on the same scale of $\frac{1}{50000}$, with more careful instruction to the topographers, and therefore with always greater perfection, so that they no longer needed a neat copy of the field-sheets, for the necessary reproduction of the topographical works a few days after having finished the survey of the country.

Photography and the heliotype process comprised at first the methods of immediate reproduction. But afterwards a new and fine invention improved it greatly. We speak of photolithography, a perfected process, taught and introduced by Colonel Castelli, of military fame.

Photographs reproduced and engraved on copper by a chemical and mechanical process, which is the inventor's secret, furnish us magnificent engravings.

Photographs transferred on stone and on zinc give us the means of reproducing in a short time any drawing.

To-day is given an original work to be photoincised, and after a month the sheet can be given to the trade, comparing favorably with the handsomest engraving on copper.

Photography is yet more rapid, and furnishes to the public (like zincography) the drawings reproduced after two or three days, and they are good enough to be used in war and by technical men.

The topographical works in the southern provinces of Italy will be terminated in the current year. The map composed from this survey will consist of 174 sheets, (348 half-sheets.) Until the present time all work executed in the country, up to the year 1874, has been reproduced by photolithography and by photozincography. The field-sheets which will be finished this year will be reproduced and given to the trade in the spring of the coming year, 1876.

Meanwhile the government thinks already of extending the survey to the other provinces of the kingdom in order to obtain a map on a large scale complete, uniform, detailed, and recent, of all Italy. But for the present, in order to make the map of Piedmont useful in 91 sheets, which is constructed on the same scale of 1 : 50,000, as it is in some respects valuable, and above all the only one existing on a large scale, they begun the correction of the stones, executing them after a careful local reconnaissance perfected by the officers attached to the Military Topographical Institute. Twenty-seven sheets have been corrected; also the chorographic map of Upper and Central Italy on the scale of 1 : 600000 is in progress of correction, and at this time two sheets have been rectified.

Here it would be well to mention the notable change which happened in the organization of the technical office which has acted as part of the staff corps since the year 1872. The considerable development of the geodetic and topographical works induced the Government to dissolve the technical office of the staff of the army, transforming it radically under the denomination Topographical Military Institute, with independent action and self-control.

The Institute began work January 1, 1873. All the works already mentioned have progressed with rapidity under the new direction with more ease and less trouble.

Besides the above-mentioned works the Institute proceeded to the survey of the vicinity of Florence and Rome, and other special locations, on the scale of 1 : 25000 and of 1 : 10000, successively reproduced by photolithography and chromolithography, and above all to the drawing and reproduction, by means of the photoincision of Avet, of a chorographic map, of 25 sheets, of the Neapolitan provinces, on the scale of 1 : 250000, reducing it from the Austrian elements found in the topographical office of Naples. These elements, on the scale of 1 : 103680, composing a map

of the Neapolitan provinces put together between 1821 and 1824, in the time of the Austrian usurpation, were copied on the scale of 1 : 125000, introducing all the corrections to the roads and hydraulic systems, and representing the mountains with the line of vertical light. These drawings, in fair hand, on the scale of 1 : 125000, were successively photoincised on the scale of 1 : 250000, (the last seven sheets in the spring of the current year,) and produced a good and fine map in many respects. So the southerly provinces of Italy, the poorest in modern maps, became all at once the richest and most advanced, thanks to the diligence of the staff and the activity of the topographical Institute.

The Institute executed in addition many maps on a large scale (1 : 5000 and 1 : 10000) for the study of war, and proceeded to a third edition, entirely revised, of the itinerary of the kingdom, adorned with a map of Italy, a chromolithograph on the scale of 1 : 1000000.

All these interesting and varied works were used in the production of a number of maps for the field exercises in 1873, '74, and '75, and many other works too numerous to mention.

But the thoughts and studies of the administration and of its scientific men and artists were involved in a greater, more durable, and definite work. We wish to speak of a general map of all Italy on the scale 1 : 100000, which was the last application of science to the construction of maps of topography. The proposition was presented to the House in order to obtain funds, and was passed. The new map will be formed of 287 sheets of the dimension of $0^{m}.41 \times 0^{m}.37$, and constructed on natural projection and based on the new and careful geodetic triangulation, the result of the great operation of the European degree measurements. The topography will by use of the plane-table give the most recent planimetric changes.

This map, the first sheets of which are already in progress, will certainly do credit to the art of Italian cartography, as well for execution as for correctness of details and beauty of reproduction.

FLORENCE, *July*, 1875.

Translated from Rivista Militare Italiana, Settembre, 1875.

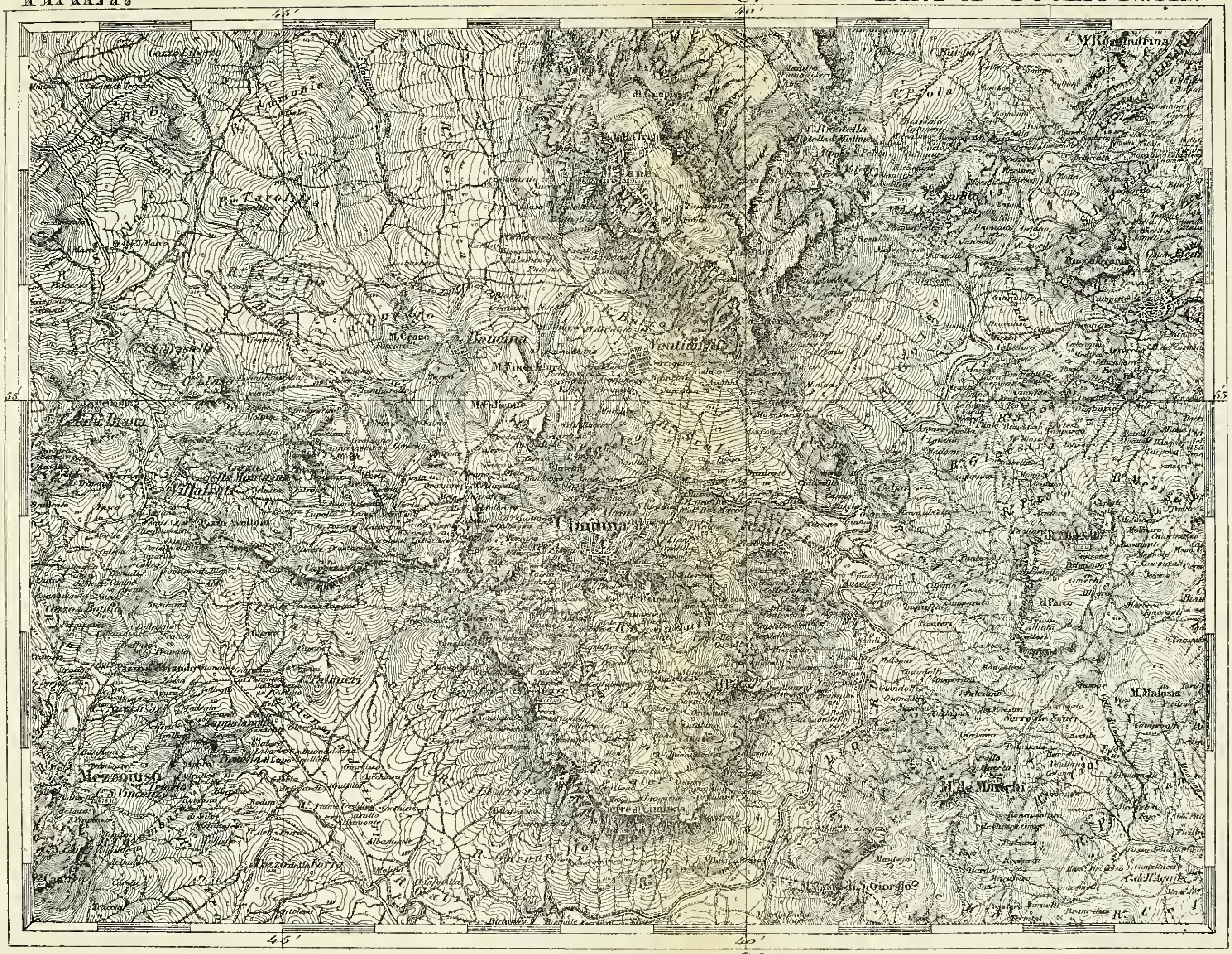
§ 2. NOTES ON MAPS OF ITALY, PUBLISHED BY THE ITALIAN MILITARY TOPOGRAPHICAL INSTITUTE.

I. A map of the Kingdom of Italy, scale 1 : 1000000, to adorn the general itinerary, third edition, revised and corrected, 1875. This is a chromolithograph, printed on 6 sheets, 20″ × 16″, to be joined in one. The border is subdivided so as to show the latitude and longitude, but no meridians or parallels are drawn. The railroads and carriage-roads, the boundaries of states and provinces, and the principal rivers are given. The whole is a compilation from old and recent surveys, and only parts of it are based on accurate survey.

II. A topographical map of the province of Naples, scale 1 : 250000, published in 1874. This work, in 25 sheets, 13½″ × 11½″, was produced by a process called "Foto-incisione," and is a reduction from Austrian surveys, scale 1 : 103680, made between 1821 and 1824. This last survey was first reduced to the scale of 1 : 125000, and the reduction further reduced by foto-incisione.

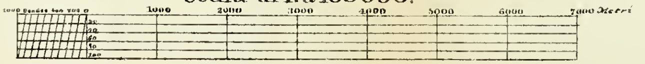
The border gives the latitude and longitude to minutes, but no meridians or parallels are drawn. The principal lines of communication, the roads, water-courses, and boundaries of provinces are given. Relief is indicated by hachures drawn and reproduced, so as to give the map a

ITALY. O° PART OF "FOGLIO No.142."



O°

Scala di 1. a 100000.



Longitude Est dal Meridiano di Parigi

Scale 1:250.000

fine appearance. The method used for reproduction, foto-incisione, compares favorably with copper-plate engraving.

III. A topographical map of Sicily, scale 1 : 100000, published in 1871. This work consists of 48 sheets, $13\frac{1}{2}'' \times 9\frac{1}{2}''$, also reproduced by foto-incisione. The meridians and parallels are given for every five minutes, and references are made on each sheet to the adjoining sheets on each side. Relief is indicated by horizontal curves 10^{m} apart in elevation. Elevations are also given by figures at various points. The water courses, boundaries of provinces, railroads, and common roads, of second, third, and fourth classes, are indicated. Trees are denoted by a letter B, ("Fosco.") Cultivation of different kinds is also indicated by letters, as V, for vineyards, ("vigni;") G, for a garden, ("giardino.")

IV. A topographical map of the southern provinces of Italy, scale 1 : 50000. This is a reproduction by photolithograph and zincograph from the original field-sheets of the survey. The surveys for some of the sheets furnished were made in 1874. It is proposed to publish the same survey on a scale of 1 : 100000. Relief is indicated by contours for every 10^{m} of elevation, and figures are frequently given to show the height of prominent points. Numerous conventional signs are used to indicate railroads, and roads of first, second, third, and fourth classes, aqueducts and bridges. The nature of the ground, whether cultivated or uncultivated, marsh, meadow, brush, trees, vineyards, and rice-fields are all indicated by established conventional signs. This work when completed will consist of 174 sheets, (or 348 half-sheets,) $20'' \times 28''$; half-sheets, $20'' \times 14''$. The projection is made by Flamsteed's method, and meridians and parallels are given for every $5'$ of arc.

V. Map of Florence and vicinity, scale 1 : 25000, published 1875, one sheet $24'' \times 21''$. This is a photolithograph, shaded and colored. Latitude and longitude are not given, and no meridians or parallels are drawn. Relief is shown by contours for every 10 meters of elevation and by shading. Figures also give the elevation at various points. Conventional signs are used as in the previous case, (IV.) Houses are shown with the names of the proprietors in the surroundings of the city. Rivers and creeks are colored blue.

In the field-work for the recent surveys the plane-table and stadia were used for topography. Points for each sheet were furnished by the triangulation.

No information in regard to the organization of the "Italian Military Topographical Institute" or in regard to the details of their work is given, except the meager account in the "Rivista Militare Italiana."

Authorities.—Copies of maps.

Compiled by Capt. H. M. Adams, Corps of Engineers.

CHAPTER VI.

§ 1. STATE OF THE WORK OF THE GEOGRAPHICAL INSTITUTE OF SPAIN ON THE 31ST OF MARCH, 1871.

GEODETIC WORK.

After the various reports of the geodetic work of the first order executed in Spain which have been published, the most convenient method of avoiding repetition and of conveying a clear idea of its actual state will be the recital of that which remains to be done in order to accom-

plish the plan projected by the government for the Geographical Institute, completing that which the old commission of maps traced out at the beginning of its work. Since the publication of the last of the above-mentioned reports coincided with the turning over of this service to the Bureau of Statistics by decree of His Highness the Regent of the kingdom, on the 4th of January, 1870, it appears natural, in order that there may be no interruption of continuity, to refer to that which on that date remained to be done in order to complete the part projected, adding that accomplished up to the present date, as well as the new works, both of observation and of computation, which have been commenced.

To complete the angular observations belonging to the fundamental systems projected, (Plate VIII,) 102 vertices remained to be occupied, on 56 of which there were to be made, moreover, observations referring to the great quadrilaterals formed by the same systems, increasing to 143 the number of the stations, which were needed in the interior of those quadrilaterals of the first order.

In addition, it was necessary to verify various surveys in order to substitute with advantage several vertices selected but not observed, and to complete the general project of triangulation, as well as to prepare conveniently with signals or mounds of stone 97 vertices. Only one base had been measured for the net-work of the Peninsula, and it was therefore necessary to project the system of bases and to measure the additional ones, connecting them with the triangulation.

With regard to the computations, the first system of equations, formed from the data collected on each station considered independently, had been solved for all the vertices on which observations had been made; but no decision having been made as to the method to be adopted for the compensation of errors, and as to what should be the division, provided they were to be distributed in independent zones or divisions, the computations undertaken had been limited to this first part. The geographical co-ordinates of none of the vertices of the system had been determined, unless we except Madrid and San Fernando, whose latitudes and difference of longitude are known from their astronomical observatories. The azimuth of none of the sides was known with the necessary precision, since sufficient exactness was wanting in the approximate value of the side Madrid-Hierro, which had been determined with the assistance of the Madrid observatory from a very small number of observations in order to satisfy the most pressing necessities.

Lastly, it had been intended to run a special line of geodetic levels which should cross the Peninsula from the ocean to the Mediterranean, but the work had not been undertaken.

Of the vast triangulations of the second and third orders which have to cover the Spanish territory, only those belonging to the Balearic Islands were completed, and those of the provinces of Madrid, Toledo, and Guipuzcoa commenced.

Before proposing the completion of the general plan of geodetic operations, the Subdirector of Statistics, now the Director of the Geographical Institute, believed it convenient to mark the limits of the two groups, essentially distinct, which the triangulation of Spain embraces. The first comprises all those works which, serving as a basis for the others and circumscribing their errors, have besides as an object the advancement of science, by collecting new data for the more perfect knowledge of the form and dimensions of the earth, operations which demand in observation the most perfect instruments, materials, and methods, and in the computations of the results all the resources of mathematics. The second group embraces the triangulations of the different orders,

designed for the graphic representation of the territory, and serving as a foundation for the topographical atlases which, for various objects, are needed by the public administration. In this work instruments more portable and of less accuracy are employed, the number of observations is reduced, and expeditious methods of computation are employed at the sacrifice of an exactness which is not absolutely necessary.

To the first group pertains the system of the ten fundamental series, the measured base and those which are to be measured in the future as the basis of the system, the determination of latitudes, longitudes, and azimuths on vertices conveniently selected, the investigations with respect to the force of gravity, and the special lines of precise leveling.

To the second group belong the triangulations of the first order which cover the interim of the great quadrilaterals formed by the fundamental series, and the geodetic net-works of the second and third order which depend upon the primary triangles and extend over the whole surface of the national territory.

Founded on that which precedes, it was proposed and approved by the Government—

1st. That the observations in the fundamental series should be continued preferably, following strictly the method which conduces to the compensation of errors by the formulas of Bessel and Baeyer, according to special instructions.

2d. That in addition to the central base, already measured, three others should be selected and measured, one of which should be situated, as already projected, in the most southern part of the Peninsula, and the other two as far north as possible, and near the eastern and western coasts.

3d. That the astronomical observatory of Madrid, concurrently with the Geographical Institute, and with due regard to the position of this scientific establishment, should commence the determination of latitudes, longitudes, and azimuths at vertices of the fundamental series conveniently chosen.

4th. That in the special leveling of precision the system agreed upon in the conferences of the International Geodetic Association for the measurement of degrees in Europe should be adopted, and that this new work should be begun immediately.

5th. That considering the fundamental series as a single system, the general compensation of errors should be commenced, solving the second group of equations which arise from the observations at each station considered independently.

6th. That the triangulations of the first order in the interior of the quadrilaterals, and those of the second and third orders, should be commenced in each district according as they may be needed to support other trigonometrical net-works. To secure the surest execution of this plan and a convenient uniformity in all the work, the following measures were adopted: Four commissions, composed of chiefs and officers of the corps of artillery, engineers, and general staff, who are detailed to the section of geodetic works of the Geographical Institute, were charged with compiling projects of instructions; the first commission for the observation of angles in the geodetic triangulations of the first order, the second for the execution of the first computations which are to be made in the same triangulations, with all the necessary models, the third for the assistants charged with the construction of the signals of the first order, and the last for the service of the heliotrope sections. These projects of instructions being presented, they were approved and printed immediately.

Another commission, similarly formed, proposed the forms of computation to solve the equations and substitute the values of the unknown quantities, after they were determined, in the work which had been commenced for the general compensation; and these, having been approved, were also printed.

The representation of the net-work of primary triangles on a small scale, which had been engraved some years previously, being insufficient for planning the numerous equations of condition, and making the other preparatory studies, because it does not contain all the observed lines, another commission traced Plate VIII, on which, with the greatest clearness, is seen the actual state of the observations.

All the directions observed from each one of the stations are indicated, and it does not contain other lines which might cause confusion. The vertices selected, but on which no station has been made, remain without being united among themselves. The directions corresponding to the systems, which constitute the work of higher geodesy, are represented by full lines.

The directors of the observatory and Institute concurrently decided that the first-mentioned establishment should proceed at once to the determination of the azimuth of the side observatory, Hierro.

To a commission of chiefs and officers belonging to the same section was intrusted the study of the works published upon levelings of precision executed in other countries, and it was charged to present a project of the general basis upon which a double line of levels between the port of Alicante and the observatory of Madrid should depend. The commission executed its task, and after the proposed bases were approved the construction of the necessary instruments was ordered.

A place was required in which it would be possible to test the instruments by submitting them to conclusive experiments of measurement before undertaking the work, and a permanent geodetic observatory was established on the flat roof of a tower in the Madrid park, which was given for this purpose by the council. From the two pillars of granite, on which two instruments can be tested at the same time, five vertices of the fundamental series are seen; and it is therefore possible to carry out completely the same observations as on a geodetic station and to make comparative tests of the different instruments employed in the primary triangulation.

Finally, the geodetical assistants were organized into two divisions, and, in addition, an elementary theoretical class in charge of one of the military chiefs was formed, to which, during the suspension of the field-work and in spare hours, is given the instruction necessary for the efficient discharge of the service confided to them.

A machine for executing with more rapidity and accuracy some of the numerical calculations was also procured.

The result of the field-work since June, 1870, has been, with respect to the fundamental series, the observation of the azimuthal directions and zenith-distances on 21 stations, 9 of which belong at the same time to quadrilaterals whose observations have also been made; the preparation with signals or stone mounds of 24 vertices; the repair of the constructions already made on 26 vertices; and the choice of 19 others belonging to the primary triangulation.

The astronomers of the Madrid observatory have made the observations necessary for determining the azimuth of the primary side—Observatory-Hierro.

In the province of Toledo, the reconnaissance for projecting the secondary triangulation, intrusted to the officers of the Corps of Topo-

graphical Engineers, has been continued; 84 vertices of the second order and 139 of the third having been selected, and the method of fixing 51 villages, which are not vertices of any of the triangles, having been prepared.

Special mention is deserved by that part of the office-work of the geodetic section, which has resulted in the resolution of the second group of equations for 94 vertices of the fundamental series, and in the solution of the first group for each one of the 21 stations occupied in the last season.

For beginning the work in April next, 9 parties, which are to continue the triangulation and commence the leveling of precision, are already prepared.

TOPOGRAPHICAL WORK.

In accordance with the order of his highness the Regent of the kingdom, in the decree of the 12th of September last, the director of the Geographical Institute formed the general plan for the topographical triangulation and the drawing of the field-sheets which are required for the publication of the map, for which the project was approved by the order of his highness, issued on the 30th of the same month, in which order it was also directed that the operations, with the extension permitted by the credits conceded by the Cortes, should be commenced immediately. This general plan of the works, in the compilation of which it was necessary to take into account the principal object which they had to satisfy; the services which they could lend successively to the different branches of the public administration; the state of advancement of the geodetic triangulations; the personnel and material of the institute, and the credit at its disposal, contains, among other things, the following directions:

"All the topographical works which are undertaken by this institute will have to be closely connected with the geodetic triangulation of the third order; but as this has been executed only in the Balearic Islands and the provinces of Madrid and Guipuzcoa, it is necessary to plan the operations in such a way that, without delaying until the geodetic triangulation covers a part of the territory determined upon, it may be possible to arrange in it a sufficient number of points of reference, trigonometrically situated, to complete later, and when the geodetic net-work has been further extended, the required connection between the geodetic triangles, which are the basis and foundations of the topographical representation and the works of detail undertaken to perfect this representation."

"To attain this object, it will be sufficient that the topographical sketches rest upon special triangulations, which in their turn can at the proper time be connected with the geodetic work of the third order. And it is not necessary that these topographical net-works should present that regularity which is generally required in the geodesy of the different orders; but, on the contrary, in consequence of their special objects, they may offer a mass of triangles of different forms and dimensions, some arranged in the form of a continuous net-work, others superposed, and nearly always without immediate relation with those of the adjacent triangulations. It is, however, important that the angles should be confined within convenient limits, and that from their vertices it may be easy to see the geodetic points, if there are such, or those points which it is probable will hereafter be made vertices of the general triangulation."

"Each of these partial triangulations must start from a short base, carefully measured by topographical methods."

"When the connection of the partial triangulations with the general geodesy of the third order has been accomplished, their azimuths will be determined, and the positions of their vertices can be calculated; but, in order that approximate azimuths may be had immediately, the necessary observations to determine its azimuth by the aid of Polaris will be made at one extremity of each base, using a theodolite which reads to ten seconds."

"At the same time that the horizontal and vertical angles are read on each vertex of the partial triangulation to the other vertices of the same, readings will also be taken to all the prominent objects of the surrounding country, such as towers, farm-houses, villages, mills, and boundary-marks, in order to connect this triangulation with the detail work."

"Each of the partial triangulations must cover the area of one or more municipal districts, and the length of the sides, which should average 2 kilometers, must not exceed 5. These triangulations will be made with repeating theodolites reading to ten seconds."

"The topographical surveys will be divided into two classes, the first of which will comprise the planimetry, and the second the hypsometry."

"The planimetry will embrace the drawing of the perimeter of each of the municipal districts at the time at which the survey is made, provided the land-marks have been set; the perimeters of the jurisdictional districts belonging to the same council, the topographic features, such as rivers, creeks, canals, roads, valleys, and groups of houses; lastly, the limits of the different kinds of cultivation whose area exceeds 10 hectares, (24.7 acres.) All these lines will be joined with the geodetic or topographical triangulation points by sights taken from the topographical stations of detail."

"The field-sketches will be drawn on a scale of $\frac{1}{25000}$, in order that the reductions which may be convenient may be afterward made."

"The second class of the topographical surveys will have as starting-points the special lines of levelings of precision and the altitudes of the geodetic vertices; as its sole object is the representation of the relief on a reduced scale, the operations will be limited to that which is strictly necessary for this special purpose. The second class will also comprehend the drawing of the topographical sketches of the towns which do not have them, but with no more details than are necessary for the publication of the map."

The general principles which precede, referring to the first class, received their complete development in some instructions compiled by a commission, presided over, according to regulations, by the director of the Geographical Institute, and composed of four chiefs of the Corps of Topographical Engineers, numerous models, which should conduce to good order and uniformity, accompanying these instructions, which in autograph form are circulated among the persons charged with these new works.

It having been determined to commence the triangulations and topographical surveys in the province of Cordova, eight parties were sent there. Each party was composed of two officers and five topographers, who worked under the immediate orders of an officer of the corps in charge of all the surveys of the province.

In the four months from the end of November to the end of March, 553 vertices for the topographical net-work of triangles have been chosen, 22 bases have been measured, and their azimuths have been determined by observations on Polaris; 347 vertices have been occupied with the theodolite; the number of stations occupied with the compass reaches 52,967; and the number of kilometers measured amounts to

8,129, and, in addition, 50 boundary-lines between different municipal districts have been finished. These operations have completed the triangulations, now approved by the director of the Institute, of the districts of Cañete de las Torres, Doña Mencia, Zuhéros, Posadas, Aguilar, Morente, Fuente-Tójar, Encenàs reales, Monturque, Cárpio, Bujalance, Pedro-Abad, Zambra, Lucena, Montilla and Cabra, which cover an area of some 156,000 hectares.

The triangulations observed, but which have not been submitted for approval, cover an area of 35,000 hectares.

There have been examined in the Institute, previous to presenting them for approval, the topographical sketches of the districts of Monturgue, Posadas, Pedro-Abad, Morento, Carpio and Bujalance, which comprise an area of 52,000 hectares, in which the planimetry is finished, and in addition the same first period is completed in 116,000 hectares of the districts of Córdova, Lucena, Encenàs reales, Cabra, Monturque, Aguilar, and Puente Genil, and in 152,000 hectares of various other districts.

So that the topographical triangulations have been observed over an extent of 506,000 hectares, and the planimetry completed in 320,000 hectares of the province of Cordova.

The province of Madrid, in which for some years works of cadastral topography have been carried on, required primarily that the topographical triangulations of the districts, in which these have been completed, should be connected with the geodetic work of the third order; that the remaining survey should be projected and the observations made; that the completed sketches should be reduced, and those which are not should be drawn, in accordance with the new instructions; and that the levelling, when it is necessary, should be finished.

The result obtained in an interval of time equal to that in Cordova, by 16 officers and 10 topographers with their provincial chief, was the selection of 360 vertices for the triangulation, the occupation of 246 vertices with the theodolite, and of 5,281 stations with the compass, the measurement of 1,070 kilometers, the making of 9,696 levelling-stations, and the fixing of 59 boundary-lines. The rest of the force has been occupied in office-work, finishing those works which were incomplete, and making the necessary reductions.

In the latter part of March, to commence the operations in the province of Seville, six parties set out, formed in the same manner as the Cordova parties, and also under the orders of an officer of the Corps of Topographical Engineers, in charge of the topographical surveys of the province.

By special command of the government, the cadastral topographical works, which are about completed, have been continued in the districts of Cartagene and Valdeolivas, in the provinces of Murcia and Cuenca. The municipalities have borne all the expenses except the salaries of the assistants.

PUBLICATION OF THE MAP.

The topographical and geodetic works of the first order having been united in one establishment and placed under the same direction, the azimuth of one side of the triangulation having been determined, orders having been given for making the levellings of precision which are to do away with the uncertainty regarding the altitude of Madrid, a force having been organized among the officers of the Corps of Topographical Engineers competent to develop in convenient proportion the triangulation of the second and third orders; this corps, composed of 300 individuals, having devoted itself to the topographical operations

which the construction of the general map of the territory requires, and lastly, the results previously obtained, with other ends in view, having been utilized, after being completed, it has been possible to plan the preliminary arrangements for the publication which all the nations of Europe, including Portugal, have at least commenced many years ago.

The general directions, which, in accordance with the proposition of the Geographical Institute, His Highness the Regent of the Kingdom has been pleased to dictate, under date of the 30th of September, 1870, are: 1st, that the publication shall be made on a scale of 1-50,000; 2d, that the map shall be divided into sheets of 20 minutes' base in the direction of the parallels by 10 minutes' altitude in the direction of the meridians; 3d, that the portion of the terrestrial surface represented on each one of the sheets shall be considered as a plane, without subjecting the map to any system of general projection.

So much for the publication on a large scale; but as this class of works is not, on account of its cost, within the reach of the public, it is necessary to study the conditions which should govern the publication of a reduced map.

In the first place is presented the question of the system which it may be convenient to employ for the projection of this reduced map, and concerning this, careful studies are being made by the chief engineer of roads, canals, and ports, who is charged with the publication of the map by the Geographical Institute. He is also occupied in examining the different systems of representation and material methods of reproduction, in order to propose those which it may be convenient to adopt in our country.

This section has devoted itself, moreover, to all the labors of the commission for the territorial division of Spain for projecting the provisional law upon the organization of the judicial power—a commission appointed by the minister of grace and justice, and to which the director of the Geographical Institute and the chief engineer of the section, who discharges the duties of secretary, belong as voting members.

ACCOUNTABILITY.

This section, composed of a chief, an assistant officer, and four clerks belonging to the civil administration, has been occupied from its creation with all the measures pertaining to an economical administration. It formed the project of instructions in force for the service of accountability of the Geographical Institute; has examined the accounts which are rendered monthly from the field by both the geodetic and topographical parties, whose total number now reaches more than 30; has made payments of bills; has assisted, as opportunity offered, all the business of the depositary of funds; has issued instruction for the necessary expenditures, and has given information to the other sections in regard to services by which expense is incurred; and, finally, it fixes the rates of pay and allowances of all the personnel. It has also had charge of the registry of letters sent and received, and of the service of the (cierre?)

Translated from "*Descripcion Geodesica de las Islas Baleares*," by Lieut. P. M. Price, Corps of Engineers.

CHAPTER VII.

§ 1. NOTES ON THE TOPOGRAPHICAL SURVEY OF SWITZERLAND.

GENERAL PLAN OF THE SURVEY AND PUBLICATION.

The Dufour chart of Switzerland is on a scale of 1 : 100000.

On the 18th of December, 1868, the Confederation resolved to have original topographical sheets made for those Cantons where no such sheets existed.

The cost was to be equally divided between the Swiss Confederation and the Cantons.

SCALES EMPLOYED.

The scale of the original topographical sheets, which are all $0^{m}.35$ long by $0^{m}.24$ high, is 1 : 50000 in the vicinity of the Alps and 1 : 25000 elsewhere.

A sheet on the 1 : 50000 scale represents a distance of $17,500^{m}$ from west to east, and $12,000^{m}$ from north to south, and contains 9.11 square stunden, (1 stunde = 4,800 meters.)

A sheet on the 1 : 25000 scale represents a distance of $8,750^{m}$ from west to east, and $6,000^{m}$ from south to north, and contains 2.28 square stunden.

The border gives the longitude and latitude after the modified Flamsteed's projection.

The sheets are also divided into rectangles of $1,500^{m}$ or $3,000^{m}$ distance from the meridian and its perpendicular at Berne.

The rectangular co-ordinates are computed from the projected geographical co-ordinates.

The published sheets are on the same scale and are scarcely changed copies of the original sheets.

The sheets on the 1 : 25000 scale are engraved on copper; those on the 1 : 50000 scale, on stone.

MATERIALS AVAILABLE.

The topographical sheets made either under General Dufour or by the Cantons subsequent to 1837, were available for the new survey. Many of these were on a scale of 1 . 100000 and without level curves.

This portion has to be done over, and all the old sheets are to be revised and corrected.

LEVEL CURVES.

The topographical work is based on triangulations of the first, second, and third orders.

The level curves are 30^{m} apart for the 1 : 50000 scale; 10^{m} for the 1 : 25000 and in exceptional cases 8^{m} and 4^{m}. Each tenth curve is broken and its height written upon it.

INSTRUMENTS.

For the 1 : 25000 scale the plane-table with vertical circle compass and stadia is used; and in the high mountain region, where the scale is 1 : 50000, a smaller plane-table without stadia is used.

ORGANIZATION OF THE SURVEY.

The survey is under the immediate charge of the chief of the staff bureau of the Swiss army—at the present time, Colonel Siegfried—and constitutes the topographical division of the bureau.

The employés of the topographical division receive their orders direct from the chief of the staff bureau, and, as a rule, by monthly programmes of work.

At the end of every month every person charged with work is required to submit a report to the chief of the staff bureau on the execution of the orders received.

The personnél of the topographical division is as follows:

1. The engineers.
2. The topographers and draughtsmen of the office.
3. The engravers on copper, and the lithographers.
4. The printers.

The engineers comprise:

a. One verification engineer.
b. One triangulation engineer.
c. A number of engineers for the revision.
d. A number of engineers for new surveys.

As a rule, the engineers who execute new surveys are paid by the square stunden of work done, a special agreement being made for each section of work given out.

The other engineers either receive yearly salaries or are paid by the day.

On the 2d of May, 1873, the chief of the staff bureau, Colonel Siegfried, fixed the price of topography at 700 to 800 francs per square stunde on the 1:25000 scale, depending on the character of the work as shown by the revision in the field.

For the 1:50000 the prices are one-half of the above.

The co-ordinates of a sufficient number of trigonometrical points are furnished to the engineers who undertake to do the topography.

A portion of the engraving and printing of the sheets is done in the office by employés at a fixed salary, but the greater part of it is done by contract with private parties.

The following synopsis of the instructions issued for the execution of the work on the different scales will show the character and scope of the survey and of the final atlas:

INSTRUCTIONS FOR TOPOGRAPHICAL WORK ON THE 1:50000 SCALE, BY GENERAL DUFOUR.

Objects to be shown.—All streams, crests of mountains and summits of hills, all roads, lakes, ponds, marshes, mines, quarries, and peat-bogs; glaciers, masses of rock, moraines, ruptures of soil; woods and vineyards, whose contours must be accurate; cities, villages, and hamlets; isolated houses are less important; bridges, ferries, and fords; roads are to be represented by black lines; water by a blue tint; dwellings in red; woods by a pale yellowish green; vineyards by pale violet; marshes by blue and green panaché; stone bridges by a red, and wooden bridges by a black line; limits of cantons by a broken red line; peat-bogs by pale brown.

Writing must be in careful round hand. The leveling is to be as precise as the instrument admits; level-curves, 30^{m} apart, in burnt sienna. Beginning and end of slopes in dotted lines and intermediate curves, if

needed, in same way. Crests of hills, heights of streams, and other important points, being fixed by leveling, the curves will be generally traced by the eye. Their object is to fix the hachures to be added after. They will give the general forms, but all abrupt accidents of the surface must be represented directly by hachures.

INSTRUCTIONS FOR THE 1:25000 SCALE, BY COLONEL SIEGFRIED, MAY, 1868.

1. *Graphic triangulation.*—The topographer must first determine by rays from the trigonometrical points the positions and heights of a great number of other points on the plane-table.

After the triangulation points, he will occupy his well-determined points.

2. *Drawing of details and topography.*—In accessible ground this will be done by stadia lines, with compass-needle and plane-table, sighting to and from all main stations. All observations are to be recorded in note-book.

Objects to be drawn.—All those of the 1 : 50000 scale, all buildings, alleys, and considerable groups of trees. Limits of individual properties, and cultivations, are not required, as these would overload the map.

Hedges that would impede troops must be given.

The conventional signs are the same as for the 1 : 50000 scale.

The heights of all important points are to be determined with the utmost precision, using geodetic methods.

Less important points for fixing level-curves, of which many are wanted, may be determined by the quadrant of reduction.

Level-curves are to be 10^{m} apart, and drawn in burnt sienna; the limits of slopes, intermediate curves, when needed, and every tenth curve, being dotted.

The heights of level-curves are to be written in brown, and of leveled points in black.

The general forms are to be given by the level curves ; base rock, by black curves, or if steep, by black hachures ; very steep and broken earth, by brown hachures.

Accuracy.—In verification the mean error of ten observations on clearly visible points from a trigonometrical station, shall not exceed 0.5^{mm}. Errors of 1.2^{mm} are not allowable.

The greatest difference in heights of leveled points when determined from three to five stations, must not exceed 5^{m}.

Elevations under 5° must habitually be used in levelling.

In projection of valleys and crests no level curve must be in error by its distance from the next; that is, no curve must be out by 10^{m} in height.

INSTRUCTIONS FOR THE REVISION OF THE SURVEY SHEETS BY COLONEL SIEGFRIED.

Triangulation.—The trigonometrical points must be permanently marked either by the setting of stones of fixed dimensions, or by cutting marks in the rocks.

Planimetry and hypsometry.—The chief of the staff bureau designates for each section the extent of the verification and revision.

The positions and heights of the points of the country are verified from the triangulation stations.

All alterations and new constructions of roads, and all changes in the towns and settlements, must be surveyed.

The cantonal and district boundaries must be surveyed.

The boundaries of forests and townships must be carefully revised.

The hypsometry must be completed, so that altitudes shall be given at the points of confluence of rivers, at bridges, and at a sufficient number of intermediate points to show the slopes of the rivers; at all towns, at road-crossings, and at a sufficient number of intermediate points to show the grades; at the summit and passes of mountain ridges, in the valleys, and at prominent points throughout the territory.

Names.—The engineer will ascertain from intelligent inhabitants the correct names of places, rivers, roads, mountains, glaciers, &c., as well as the local methods of spelling such names. He must also obtain the popular names of parts of the terrain which form topographical districts, such as valleys, gorges, plains, plateaux, &c.

As results of the revision the following documents are required:

a. The verification record.

b. A drawing on the scale of the original containing the surveyed alterations and corrections, and the corrected and completed nomenclature.

c. The field-book for hypsometrical observations.

d. A record of altitudes according to form.

e. A list of names, with the different methods of spelling the same, and the authorities therefor.

f. A list of streets and roads, containing, in the columns from 3 to 3, the distances in marching time, the widths, greatest grades, and the classification of the roads.

RESULTS ACCOMPLISHED AT THE END OF THE YEAR 1874.

A general chart of Switzerland in four sheets, on a scale of 1:250000, has been completed and published.

The Topographical Atlas, when finished, will include 546 sheets on the 1:25000 and 1:50000 scale.

The survey and revision of 161 sheets has been completed. Of these 161 sheets, 75 have been published, 26 are in the hands of the engraver, and 60 are ready for the engraver.

The Dufour map of Switzerland, on a scale of 1:100000 was begun in 1837, and completed several years ago.

It is corrected for changes from time to time.

Authorities.—Instruction pour les levés au 50m., Général Dufour (1:50000). Für topographische Aufnahme im Maasstab 1:25000. Colonel Siegfried, 1868, Erläuterungen zum topographischen Atlas der Schweiz. Organisation des Stabs-Bureau: Topographische Abtheilung, by Colonel Siegfried, 1875.

Arranged by Lieut. P. M. Price, Corps of Engineers.

SWITZERLAND

Part of PLATE XII

Scale $\frac{1}{100000}$

Date 1860

CHAPTER VIII.

§ 1.—MEMOIR ON SWEDISH SURVEYS, BY COL. VICTOR VON VEGESACK, CHIEF OF THE TOPOGRAPHICAL DIVISION.

TOPOGRAPHICAL DIVISION OF THE
GENERAL STAFF, No. 131,
Stockholm, November 16, 1875.

STATISTICS RELATING TO THE GEODETIC AND TOPOGRAPHICAL WORKS EXECUTED AND IN PROGRESS IN SWEDEN, THEIR EXTENSION, PRESENT CONDITION, COST, ETC.

ORGANIZATION.

Before topographical surveys, map-making, and description of the country were intrusted to a special corps organized for that purpose, such work was attended to by other officials or by private parties.

When the Swedish land-survey was established, in 1603, its main object was work of a geographical character, surveys of private property being only secondary. Bureus, the first chief of the land-survey, published, as early as 1626, a condensed map of the whole kingdom, and afterward maps of Svea-land,[1*] Gotha-land, and Finland, and of several Swedish and Finnish provinces.

During the next forty years the work on larger maps came to a close, but was revived by King Charles XI, who, in 1683, issued instructions for the land-survey.

The land-survey received a first change in its course of action through the ordinance concerning *skiftena*, (the shares,) or the division of the village communities into independent lots. This change was made in 1743. In 1765 the geographical work had to give way entirely to the "shares," and was not attended to again until seventy years afterward, and then but slightly. During this interval, Baron S. G. Hermelin, a Swedish geographer of high merit, made explorations in Westerbotten and Lappmarken, and published maps of Norrland and Finland.

The government[2] granted him the privilege of publishing for a period of fifteen years provincial maps of Sweden, in accordance with an adopted plan. For the central and southern provinces "hemman maps" were compiled, and ever since 1798 there had been in progress astronomical determinations of geographical positions, the need of which had by this time become sensibly felt. During ten years sixteen maps were published by Baron Hermelin. In 1809 his lack of means threatened to stop the map-work, and it was offered to the government for redemption, but the Assembly of the Diet refused to appropriate the necessary funds. Two private individuals, the Barons Bonde and Adelswärd, then came forward, with whom Hermelin agreed to form a stock company, assuming the name of "Geografiska Turättningen," (the geographical institution,) and five of the maps bear the name of this firm. There are altogether thirty-one maps in the Hermelin collection, of which twenty-two were constructed by C. P. Hällström. The proposition made in 1809 to transfer the map-establishment to the government was again brought forward in the Diet of 1823. The assembly this time gave its consent, and the map-work was transferred to the previously-organized land-survey office. No new maps were published while it was in charge of this office.

The charts were compiled exclusively from the land-survey operations,

* See note at the end.

and consequently those of Hermelin are insufficient for military use, being published on small scales, not showing the relief of the ground, or the timber, and the swampy land only in part. The need of maps with good topography, felt during the many wars in Europe since 1792, gave in most countries the first impetus toward the formation of extensive connected topographical atlases, which were afterward and are still executed by military corps organized for that special purpose.

Rather comprehensive Swedish military maps were in course of preparation as early as the beginning of 1770, in the neighboring country of Finland, under the direction of Major-General Sprengporten and Colonel Klercker. There are in existence also earlier Pomeranian and Norwegian boundary maps prepared by the Royal Fortification Corps, which are a credit to those who executed them. An entirely new epoch in Swedish topographical operations was introduced in 1805, when, at the suggestion of Maj. Gen. G. W. af Tibell, the Swedish Field Survey Corps was established. By the royal letter of April 16, 1805, and instructions of 1806, the object of this corps was declared to be to compile in time of peace complete military maps of the kingdom based on trigonometrical and astronomical observations, accompanied by topographical, statistical, and military descriptions. Necessary instructions for the execution of this work were given, among which were, that the scale for the field-work and the preliminary map should be 1 : 20000, and for the so-called special maps which were to be compiled from them 1:100000, and that the corps in time of war, in co-operation with the general staff of the army, should perform such duties as in most countries belong to the staff of a quartermaster-general. In conformity with this, by royal order of 1806, the title of "quartermaster-general," which subsequently has been applied to the chief of the fortification corps, was conferred on the chief of the field-survey corps. The balance of the force consisted of one lieutenant-general quartermaster, one major, one professor, four captains, (of whom two were adjutants,) six first lieutenants, six second lieutenants, one clerk, and two draughtsmen. To the corps was joined a bureau called "archives of war," where all government collections of domestic and foreign military maps, &c., formerly scattered in various places, were deposited, and funds were appropriated to increase the collections of the archives by yearly purchases of maps, books, and instruments.

At the time of the Diet of 1809 the idea seems to have gained ground that the field-survey had been wrongly separated from the fortification corps and ought to be reunited with it, economy being held forth as the motive for this union. The result was not entirely satisfactory. The government declared in 1811 that both corps should be placed under one common chief, to which position, by general order of July 3, of the same year, Maj. Gen. af Tibell was appointed. Shortly afterward it was ordered by the government that the corps thus united should bear the name of "The Royal Engineer Corps," but remain divided into two "brigades," the fortification and the field-survey brigade, each of which maintaining its order of promotion, should continue with the same duties which had hitherto been prescribed for it. The saving was slight and the union loose. It continued for twenty years.

Doubts as to the practicability of the union with the fortification-corps were expressed officially in 1814, principally on account of the duties which in the field fell on the field-survey brigade. Explorations, projects for trails, camps, positions, quarters, defenses, and the like, which in time of war belong to officers of the field-survey, have the most intimate connection with the services of the general staff, for which

reason the brigade ought *then* to be in co-operation with the staff, and only in time of peace be separated from it. It was not until 1830, however, that in Sweden the question of the separation of the two brigades was brought up in earnest. This course was advised mainly by the then chief of the engineer corps; after which, in 1831, the government ordered that the field survey brigade should be separated from the engineer corps, and, under the name of the topographical corps, should form a special division of the general staff placed under the command of the adjutant-general of the army in all concerning the inspection of the corps and the general arrangement of the work. The new chief, the then brigade chief, Colonel Akrell, took charge and continued for a quarter of a century to devote his active care to the art of topography. In 1856 he resigned, and was succeeded by Col. J. A. Hazelius.

By a royal order issued in 1831, the topographical corps was completely organized. The force was to consist of one colonel and chief, one major, one professor, three captains, six lieutenants, one draughtsman, and one messenger.

Since January 1, 1874, the topographical corps has been dissolved and united with the re-organized general staff. The topographical work is now executed by the "topographical division of the general staff."

FORCE EMPLOYED AT THE MAP ESTABLISHMENT.

Some officers of the army had already served from 1805 to 1815 in the field-survey corps. To hasten the surveys, it was directed in 1821 that officers with some skill in map-drawing should be ordered from the army every year as assistants in the summer-work of the field-survey brigade. If this assistance was required at that time, it was still more called for when, through the organization of 1831, the strength of the corps from 21 persons, to which it had shortly before amounted, gradually decreased to 11 officers of the regular service.

In 1834, a rule was established that to fill the places of second lieutenants withdrawn, a number of army officers sufficient for the work at the time should be detailed, and together with the topographical officers and under the command of the latter, should make field-surveys and work pertaining thereto; these officers being required to have as much skill in field-surveying and map-drawing as is demanded of the cadets at graduation. In this way, the map-work was hastened and the army officers gained experience in surveying. But most of the officers detailed served altogether too short a time to benefit the map-work in proportion to the expense. Experience has proved that two or more summers, according to different natural talent, are required for gaining sufficient skill in complete field-surveying; and as according to custom only one-third continues the third summer, when the principal gain for the map-work would begin, in 1847 it was ordered that there should be employed for continuous service, for a term of three years, six or at most eight officers who had previously served in the corps at least one year. The number of applicants was never equal to the demand. To supply the deficiency and to have a permanent working force at command, the royal majesty[2] permitted in 1858, at the request of the chief, the employment in the corps of eight sub-officers (*guider*) who were to devote themselves exclusively to map-drawing, in order to attain the technical skill desired. At the end of 1873, shortly before the topographical corps was entirely united with the general staff, these sub-officers were relieved, but those wishing to continue to devote their

time to map-drawing were retained under the name of extra assistants. Three of these who had for some years been engaged in map-engraving were employed as engravers.

To show how large a force is generally engaged in the topographical work, it may be mentioned that in the summer of 1875, 28 persons took part, among whom were 8 officers, a professor, and two aspirants, belonging to the general staff, 12 officers of the army, and 5 civil assistants. This year 24 persons were engaged on the winter work, of whom 10 belong to the general staff, 5 are civil assistants, and 9 are officers detailed from the army. The number of engravers is at present 7.

THE PROJECTION OF THE MAP.

The method of projection adopted for the Swedish atlas was worked out in 1816 by Second Lieut. Count C. G. Spens. It was regarded as important, for a comprehensive military map for field use, that as large a territory as can at once be surveyed by the eye should take, without noticeable error, a conformable shape on the paper. Count Spens calls this quality "correctness of contour." It exists in two older projections, "the stereographic" and the "increasing cylindrical," but as the simplicity of the projection net was regarded as being of particular importance, satisfaction could not be obtained from the former, in which, when the compression is considered, meridians and parallels are indicated by ellipses or by circles. The increasing cylindrical projection, again, causes such a considerable change in the scale that it is seldom used, except when one is to be guided by compass, as for lake charts. Its chief property, that the scale increases from the middle toward north and south, was by Spens applied to the conical class, and he thus became the inventor of a new method, which he called "the increasing conical projection." The projection error in the increasing conical method, as in the stereographic, consists in the changeableness of the scale. It is so arranged that the error becomes equal at both borders of the map in north and south, and in the direction at right angles, somewhere in the middle. The projection belongs, consequently, to that part of the conical class called "intersecting," and is such that the projected surface, to its minutest parts, conforms to the one to be represented. The scale is a little too small at the middle of the map, at the north and south borders a little too large, and at the two latitudes correct.

In the documents of the Royal Scientific Academy for 1817, the inventor has given a complete investigation of the formulæ pertaining to this method. From these it will be found that the inner maximum of the error does not strike midway between the limits, neither do the correct parallels come half-way between the center and the borders, as is still usually assumed.

The whole calculation extends from the borders of the map. For these borders were selected the most southerly cape of the province of Schonen and the most northerly bay of Botany Bay. No map on a large scale seemed to be required north of this bay, and even if the map was to be extended over Lapland and Finnmarken, it was thought better to place a greater error in those out-of-the-way places, so as to have the more southerly and more thickly inhabited territories better represented. The meridians are indicated by straight lines and the parallel circles by concentric circles. The cone by whose development the map is obtained intersects the spheroidal globe along two parallels, 56° 57′ 31.5″ and 64° 22′ 59.5″, at which points the error of

the projection is zero. The greatest projection-error amounts to 0.0021, and occurs at the adopted boundary latitudes in north and south (*i. e.*, 65° 50′ 20.4″ and 55° 21′ 19.4″) and at the degree of latitude which is equal to half of the conical angle, or to 60° 44′ 29.6″.

The compression of the globe is in the Swedish projection net assumed $=\frac{1}{304.2607}$ and the radius at the equator = 6376797.06 meters, which figures were at that time looked upon as being the most probable. To approximate these after every new observation has been regarded as leading to confusion rather than to advantage, and consequently they have been retained in the calculation of the triangulation net.

For the principal meridian that is adopted which runs 5° west of Stockholm Observatory, and which is also very nearly the same as the central meridian of the Scandinavian peninsula.

DIVISION INTO SHEETS.

In accordance with the plan adopted by the government for the Scandinavian map-work of 1816, it was determined that for the Swedish military-map work the sheets should be of a rectangular form 594^{mm} long and 445^{mm} wide. The principal meridian makes one side border on all sheets where it is to appear; the other sheets have two sides parallel to it, and two at right angles. The sheets are numbered with Roman numbers sideways in both directions from the principal meridian, while their position east or west of this line is indicated by Ö (for Öster=east) or V (for Vester=west.)

In the north and south directions the sheets are numbered with Arabic figures, counting from the perpendicular to the principal meridian at the nearest full degree north of the peninsula, or 72°. Thus, for example, Stockholm on the sheet is V Ö 32. Each sheet is named after some city or other place of note within its boundaries.

The whole atlas comprises 232 sheets, if Lapland is included. The area of the whole kingdom, however, corresponds to only 169 full sheets. Each sheet contains 2,644.55 square kilometers. The area of the whole country, including the larger lakes, is very nearly 8,046 Swedish geographical square miles.

TRIANGULATION.

The oldest Swedish triangulation net known was laid out by N. Schenmark in 1758 to 1761, from Cimbrishamn, in Schoonen, along the coast to the boundary of Norway. The net is narrow in some places, and the defective instruments which were then used and a want of care in the reduction of the angles prevent its acceptance as reliable. It is, however, the only case in olden time in Sweden where an idea of triangulation on a large scale has been carried out. During the forty years following various coast-triangulations were executed for the compilation of lake charts separately for each locality, and often with very little connection. Some of these surveys are regarded as unreliable; concerning others only incomplete information remains.

The first attempt of the field-survey corps in this direction in 1807 between Stockholm and Upsal led to no other result than giving the officers practice in field-work. In the same year a triangulation was made of the city of Stockholm.

In 1812, triangulation-nets were laid out along the whole coast of Schoonen. The measured base was 6,207.421 meters. The nets were based on Lund Observatory. The number of signal-stations was 52, of which two were in Denmark. No intermediate stations were fixed, and

the positions of the signal-stations were not designated by permanent marks, for which reason the net was of use only during that survey. A new net through the same province, but which extended farther into the country, had therefore to be laid out 26 years later. The point of reference for the whole Swedish triangulation net is the Observatory of Stockholm, beside which the Observatory of Lund had been connected by a special survey conducted by the Royal Scientific Academy with the main triangulation of the topographical corps. As a check on the work, latitudes were observed at several of the triangulation-stations. The position of the net is fixed by the determination of the azimuth of one of the sides of a triangle extending from Stockholm Observatory. Azimuth observations were also made at several other points for the sake of checking.

Besides the base-line in Schoonen, mentioned above, four others were measured—the first in 1815, on the southwest coast, near the city of Laholm; the second base was chosen on Lake Wœnar; the third on Lake Wetter. Both of these were measured in 1820. The fourth was located in the archipelago of Stockholm, across the bay of Mysingen. It was not until 1827 that the winter was cold enough to admit of its measurement. These four, besides the one in Schoonen, are measured with an apparatus of wooden rods, and consequently cannot be regarded as quite reliable. The lengths of these bases are: Laholm, 13,314.132 meters; Wœnar, 15,135.763 meters; Wetter, 16,816.109 meters; Mysingen, 14,300.609 meters.

New measurements of base-lines have since been undertaken, six of which may claim to satisfy all the requirements of the present time as to accuracy. Among these was one measured in 1839 and 1840, in Oeland, by the Topographical Corps, with the base-measuring apparatus which was used by Bessel in East Prussia in his measurement of an arc of the meridian. For the site of this base-line the elevated limestone plateau which, under the name of Alvaren, runs along the island Oeland was selected. The base was measured twice, in accordance with the present custom.

The first measurement, in 1839, gave, according to one observer's reading, 5,473.071 meters; according to the other observer's reading, 5,473.084 meters; mean, 5,473.0775. The second measurement, in 1840, gave, according to one observer's reading, 5,473.082 meters; according to the other observer's reading, 5,473.092 meters; mean, 5,473.0880. The mean of the measurements of the two years is consequently=5,473.0877 meters.

The extremities of the base-line were marked by two stone pillars, cut smooth at the top, with masonry foundation, and over which arches were built.

In 1863 three base-lines were measured for the Central European measurement of degrees, under the superintendence of the Swedish Scientific Academy, with an entirely new base-apparatus, made by Berg, of Stockholm. This base-apparatus is, in the main, similar to the one constructed by Struve, but with some important alterations, made by Major-General Wrede, which considerably simplify its use.

As something remarkable, may be mentioned that in the measurement of one of the bases, during a full day, as many as 270 rods were laid out; and to show with what accuracy one can measure with this apparatus, may be stated that in one of the bases which was measured twice the discrepancy amounted to only 0.0029 meters.

The base-lines are, one on Ladugards gärde, near Stockholm, 2,295.045 meters long, connected with the triangle side Lökenäs-Trindtorp by a

triangulation net comprising 13 stations. The second base was measured on the sandy plain at the mouth of Laga River, in Halland, 6,923.732 meters long, connected with the triangle side Wilse-Härad-Knösen by a system of six stations. The third base, measured on Axevalla heath, in West Gothland, is 2,618.667 meters long, and connected with the sides in the main triangle Skära-Kinnekulle-Billingen by a net comprising 10 triangulation-stations.

Two base-lines were measured by the topographical corps in 1870 and 1873, at Fahlun and at Umeå, with the above-mentioned apparatus, which was borrowed from the scientific academy. The former of these bases has a length of 4,099.600 meters, and for the latter, which was measured twice, were obtained the lengths 3,189.0452 and 3,189.0479, or, when the mean of the results is taken, 3,189.0465 meters.

The forest of Swedmoften prevents the determining beforehand of where the main lines of the net should run. The features of the country and the need of economizing have necessitated a preliminary examination to find where it may be possible to carry through the triangulation net. Hardest to pass are the limits between the provinces, where the ground is generally rough. Next in difficulty are the mining and manufacturing districts. Easiest is the archipelago, next are the territories where an originally Finnish population has, through persistent clearing of the land, prepared an open view.

The length of the sides, consequently, had to depend on circumstances, and cannot be even approximately stated. There are some which are hardly 5,344 meters. One (Omberg-Taberg) is 77,391.161 meters. Forty thousand meters is regarded as inconvenient, and 20,000 meters is the best. Signals have usually consisted of pyramids, covered with boards nailed on at short intervals, and with a black barrel or a white target on top. The points where the signals have stood are designated by durable marks, either iron plugs inserted and secured in the mountain or by marks cut in the rock.

The location of the net and the building of the signals are attended to by the officers. Angle observations are made partly by professors and partly by the officers of the Topographical Corps or of the general staff. The professor is accompanied in this work by an officer to assist and to learn.

Three larger and six smaller theodolites were used in the survey. The oldest was made by Reichenbach and Liebherr, and has diameter of limb = 0.4314 meters. One with diameter of limb = 0.32026 meters was received, in 1834, from Littmann, of Stockholm. Each has 4 verniers, which read to 4 seconds and may be estimated to 2 seconds.

Since 1871, an excellent universal instrument, made by Repsold, of Hamburg, has been used in the primary triangulation. It is constructed with a broken tube, and has horizontal and vertical circles of 12 and 10 Parisian inches respectively. In reading, microscopes are used. The instrument has given results which, as regards accuracy, leave nothing to be desired.

In some places astronomical locations were resorted to, but have proved unsatisfactory, on account of their unreliability. An attempt was then made to ascertain whether small triangles could be carried through where large ones were unattainable. This caused the use of smaller theodolites, suitable for triangulation-lines of the second order, extending from the main system. Observation and calculation occupy here about the same time for the same distance in miles. The principal advantage of the smaller instruments is that they can be more easily

transported to and from the stations. Three were made by Littmann, of Stockholm, and three by Jünger, of Copenhagen.

At the present time a triangulation net of the first order stretches along the entire coast of Sweden from Svinesund to Torneå. Besides this, and in connection with it, systems of triangulation have been laid out with the same accuracy in the direction of meridians and parallels. Triangulations of the second and lower orders within the lines of the main system have in these parts of the country within a short period given points sufficient in number for the atlas. Northern Sweden has as yet few geographical positions, but, as the final triangulation of the southern and central parts of the country is soon to be completed, the geodetic work in that part of the country can be carried on with more energy.

LEVELING OPERATIONS.

In former times no particular importance was anywhere attached to the rise and fall of the ground. In this country it was necessary not to divide among too many works the small appropriations and the limited force which could be employed on the map-work. When noticed, however, that Sweden stood alone in this, the observation of altitudes began to be attended to at first only as secondary work, in connection with astronomical observations and triangulation. But little time was given for this purpose, nor could suitable locations always be obtained; for if the point is not situated either on a water-course or on a water-shed, the knowledge of its elevation is of little value. During the last two decenniums a complete examination of the ground features has been made, partly by the topographical corps and partly by the office in charge of the Swedish geological survey. The works of the different offices are performed on a common plan and in connection with one another.

The examinations are made by leveling, and start from the mean water-level of the Cattegat and the East Sea, (Baltic,) which has been obtained from observations on the water-heights made at the light-houses during many years in succession. Lines of levels are run across the country from sea to sea. The east and west lines are combined with lines running north and south. From these main or check lines extend detail-lines, through which points sufficient in number are determined for the requirements of the map; 30 to 40 points are generally included within 114 square kilometers. (See further the method of working on the scale of 1:50000.)

During late years trigonometrical leveling has been connected with all triangulations.

SKELETON MAPS.

In Sweden, for more than twenty years, a bureau has existed called "Central Archives," the general land-survey office, where copies of all geometrical maps are preserved; and in the provinces a special department, called "Provincial Archives," for the original maps. These maps, through their number and the large scale (1:4000) on which they are usually constructed, give an opportunity for simplification which has not been neglected in the military map-making of the country. Thus, with the aid of the means just referred to, a so-called skeleton map has been compiled since 1828. The skeleton map is put together in the following manner: Those geometrical maps retained in the land-survey archives which are not from age or from other reasons regarded as useless are reduced to the scale adopted for the field-survey. When land-survey maps could not be obtained, the interval has been filled either by

distance-measurements, or, when the triangulation-net was distant, a base-line was measured on the ice the previous winter and a smaller triangulation-net extended from it; occasionally the complete survey by land-surveyors on the ice of one or more lakes or morasses has been provided for. After these preparations, when a number of larger or smaller map-pieces has been collected, they are put together to form a whole. This putting together is carried out in the following manner: On a large table, with a perfectly plane top, all the triangulation-points, spherical as well as plane, are plotted according to scale. These points are located during the triangulation proper with reference to surrounding objects, so that they can be plotted each on its respective piece. Each such piece is now laid over the corresponding triangulation-points on the table and is attached thereto with a needle, which is pricked through the point on the paper. Next are arranged round these all the remaining pieces in their proper positions, which can be ascertained from the inscriptions round the borders of each piece. All that now remains is to move and fit these numerous pieces so that they become one harmonious whole, taking special care that those pieces on which the triangulation-points are remain perfectly undisturbed. Small errors exist throughout the whole, partly from the shrinking of the paper, partly from possible mistakes in the survey, and these errors must be so distributed over the whole surface that the unavoidable overlappings and intervals become the smallest possible. This requires continual fitting and adjusting; a work which demands considerable experience, accuracy, and skill.

When at last all the pieces have been made to fit, they are glued together, the sides are drawn at right angles, and the sheets are cut apart and frames glued to them. The skeleton-map is then ready, and contains, or should contain, all the outlines of the territory to be surveyed. It is then divided into working-sheets of suitable size, and each sheet is transferred to tracing-paper, from which the sketching, by means of tinted paper, is again printed on the paper on which the survey is to be made.

Such has, up to the present time, been the method of constructing the skeleton-map. A different method will hereafter be adopted, since the government economy map-establishment has been, since 1873, placed under the command of the chief of the topographical division of the general staff. This map-establishment is preparing, with the aid of the locations of the topographical division, and with the same projection method, a plane-map of the central and southern parts of the kingdom on the scale 1:20,000. In those parts of the country where the works of the economy map-establishment precede the military survey on the scale 1:50,000, the economy map will be reduced to said scale and the field-survey made on a copy of the same. (See further on in "the working method" on the scale of 1:50,000, and those works executed by the economy map-establishment in the survey of the skeleton-map on the scale 1:20,000.)

METHODS OF WORKING IN THE DIFFERENT SCALES.

In Sweden the following scales are used for different purposes: 1:1,000,000 for the general staff; 1:200,000 for the "Län" maps[5]; 1:100,000 for the special map; 1:50,000 for the field-work of the special map, or the so-called concept-map; 1:20,000 for pass and position maps; 1:10,000 for more important passes and positions. For special purposes, surveys on still larger scales have been made, as 1:5,000 and 1:1,000.

The work in the field for the military map was at first executed on

the scale 1 : 100,000, on which scale maps were made of the whole coast and of a great part of Central Sweden, or the whole territory around and between the large lakes Wenner, Wetter, Hjelmar, and Mœlar, in all an area of about 160,000 square kilometers. During this work, the difficulty of producing a sufficiently accurate and complete map of a land like Sweden, with subdivisions into such small tracts, and with the field-sketching not made on a larger scale, was fully recognized. For this reason the scale for the field-survey was changed in 1844 to 1 : 50,000, which has ever since been used for this purpose, and on this scale maps have been constructed of an area of about 65,000 square kilometers in the southern part of the country.

The field-survey, for which the surveyors are divided into parties of 8 to 10 officers, under the orders of a general-staff officer, is executed with all the accuracy that the scale will admit of.

On the scales 1 : 1,000 and 1 : 10,000 the smaller territories only are surveyed as cities, forts, and intrenchments, with their immediate surroundings, especially important passes and positions.

If the territory to be delineated is large, so much so that its outline cannot be included on one working-sheet, (or plane-table,) then it may be expedient to begin the work with plane-triangulation, which, if special accuracy is required, is done with a theodolite. Skeleton-maps are never used for those scales, because the errors would, with a comparatively slight reduction of possibly existing detail-maps on larger scales, be altogether too distinct and damaging in proportion to the accuracy demanded. For the larger scales, 1 : 1,000, 1 : 5,000, as a general thing, no detail-maps large enough are to be found which can be used for this purpose.

All objects, natural and artificial, are sketched according to their real size and shape, and hence the map is a complete horizontal projection. Lines of communication of all kinds generally form exceptions to this. The relief of the ground in the territory is designated only by the projections of equidistant horizontal contour-lines. The altitudes are reckoned from the lowest point of the territory. The plane-survey and the contour-sketching are made separately. For sighting, the index-ruler is used. Distances are measured by chain, fathom-rod, or stadia, but never by stepping. All elevations are taken with the level, and only exceptionally, in dense woods or in otherwise unimportant places, with the level-mirror.

The scale 1 : 20,000.—This scale is in Sweden used principally for surveys of passes and battle-positions, (and is therefore commonly called the "position-scale,") or smaller parts of the country which for some reason or other may be of particular importance. On this scale also such works are drawn on the skeleton-map as are compiled for the use of the special map. The skeleton-map can also be advantageously used on this scale if good land-surveyors' maps can be obtained.

Spherical and plane triangulations are made in the usual order, depending on the size of the territory. Such work is of course always done on those economy maps which are prepared on this scale, and serve as a basis for the topographical works. Artificial objects are, as far as the scale admits of, plotted to their real size and shape. Standard model-sketches show in what cases exceptions are permitted. The relief of the ground is generally represented by hachure-lines, which are sketched simultaneously with the plane-survey. Equidistant curves may also be used for this purpose ; in which case, however, the plane-survey ought to have preceded.

The hachure-lines (the shortest slope-lines of the ground) are alto-

gether sketched by eye, and thus the "gradienter" gives the slope-angles and the leveling-mirror informs of doubtful relative heights. The features of the ground are next ascertained with the level, after which the map is finally redrawn. The result of the leveling is thus regarded as decisive, and at the same time this manner of proceeding effects a great saving of time, as the plane-survey and the relief-sketching can be done together. Besides, the best plan of leveling can be adopted, so that all necessary altitudes can be obtained in the easiest way. This could not otherwise possibly be done without the very roundabout way, which is, however, in principle the most correct, of first making a plane-survey of the ground, then working out the elevations, and finally sketching in the relief by eye. The projections of the horizontal section-lines, if this expression may be used, are obtained by means of horizontal sights with the level and leveling-mirror, as has been described above.

The setting up of the plane-table (orientation) should, wherever possible, be done by sighting to known points. Horizontal angles are measured by the common index-ruler. Distances are measured by fathom-rod or stepping.

The scale 1 : 50,000 is the preliminary scale for the special map which is prepared by the topographical division of the general staff on the following basis: The results of the geographical locations made by the topographical division of the general staff are delivered to a special skeleton-map establishment (Sweden's economy map-establishment) where they are used as bases for the economy map of the whole country, on the scale of 1 : 20,000, which is prepared by that establishment. This map, which contains all the outlines, or the total result of the plane-survey, is reduced to the scale 1 : 50,000 by the pantograph, after which it is put together in rectangular sheets 594^{mm} in length, and 445^{mm} in width, four of which will thus make one whole sheet of the topographical atlas on the scale 1 : 100,000. Every such skeleton-map sheet is divided either by parish-limits, or by straight lines into sections of optional size and form, but calculated to furnish work in the field for two or three weeks. These working-sheets are copied one by one on tracing-paper, after which they are, by means of tinted paper, transferred to vellum paper of the size decided on for the working-sheets. Skeleton-maps are also occasionally compiled by the topographical division in the manner previously described.

On these working-sheets the field-work is done with the plane-table, (a compass being fitted into the board,) index-ruler, and stepping. The orientation is done by compass. Hills are represented by hachure-lines, and mountains by horizontal section-lines. Slope angles are estimated by eye or by the aid of a slope-measurer, after which the drawing is finished with pencil.

During the progress of reconnaissance, data are collected for the description which every field-surveyor has to attach to his map. He carries for this purpose a note-book containing the columns marked in which the data are to be inserted, and the questions he has both to ask and to answer. This description contains all such strictly topographical and military information as the map cannot give, chiefly concerning the passability of the ground, or its adaptability for the movements of troops, consequently the slopes of hills or mountains, the accessibility of valleys, the depth of marshes, density of woods, crossing of water-courses, strength of bridges, condition of communication, routes, &c., all according to fixed instructions. To the description belongs also a name- and dwelling-list, giving an account of all inhabited localities

existing within the territory, industrial enterprises, &c. The chief of a field-survey division collects all these descriptions and condenses them to parish and provincial descriptions, which are afterwards deposited in the war archives.

The drawing in ink of the concept map progresses with the work in the field. When all the working-sheets are thus completed they are put together, the different field-surveyors paying particular attention to each other's limits to secure a perfect fit.

Lakes and all large streams are tinted light blue before the working-sheets are delivered. After the concept sheet is put together, all wagon-roads, homesteads, and boundary-lines are also tinted with their respective colors.

The finished concept-sheets are deposited in the war archives, where they are kept and photographed. Next, the irregularities of the ground are examined, and the photographs serve to make up plans for the check as well as the detail leveling.

All elevations are, as mentioned before, taken with the level. One or more check-lines are at first run through the territory, which is done with the utmost degree of accuracy. The same line is simultaneously examined by two persons, (each with his instrument,) who constantly compare notes with one another, and as soon as any noteworthy difference appears they at once re-level that part of the line passed over since the last checking took place. In that way every error, even the smallest, is discovered, and thus can the final error for a line of 100 to 150 kilometers be reduced to a mere trifle. On the check-line are established numerous bench-marks which are afterwards to form starting-points for the detail-lines. They are by preference chosen at or near by road-crossings, and are fully described in the notes, being placed on rocks or immovable stones, on the foundations of church walls, stone bridges, or in other places where it can be assumed that they will remain uninjured by time or human hands.

Errors are distributed for the check-lines separately, with the sea-level for starting and termination points. Thus the observations of the water-height which have been taken during a long succession of years several times a day, and are still made at certain light-houses along the coast, serve to establish the mean water-level from which the elevations are reckoned. From these bench-marks starts the detail examination which forms a net of surveyed lines over the whole country, through which a perpetual control of the accuracy of the survey is obtained. Only an error of 0.2 or 0.3 meters is allowed in the control survey, and if the excess is greater a resurvey is made. The distribution of errors takes place between the check-lines, through whose altitudes, which are as nearly as possible absolutely correct, values of the actual errors of the detail-lines are obtained. From these lines of the second order branch on each side numerous smaller ones for getting the elevations of isolated points, running streams, and other objects, which values are in their turn corrected after all errors are distributed.

To this examination of ground irregularities great attention is paid in Sweden, as can be seen by a glance at the special map, where generally all, even the smallest, waters are examined, and seldom any point of note is left without an elevation figure. It is also performed with a considerable degree of accuracy. All these figures are put down on the concept map on the scale 1 : 50000, which is now reduced to 1 : 100000, or the scale in which the atlas is published. The altitude figures serve now for connection and control in the reduction of the ground, which must of course agree with them. The reduction is made partly with a

pantograph (the contours) and partly by squares. The map is finished in india-ink, and is colored like the concept.

This reduction is a work which requires much experience and judgment, as will be easily seen when it is considered that there is only one-quarter of the space on the concept for representing the same thing. When, therefore, as is often the case, the concept-map is already overloaded with objects, many of which cannot be shown on the reduced scale, a selection must be made and the important be set forth at the expense of the unimportant.

One must exclude in one place and crowd together in another, but all this so that the main character of the map is not lost, and that the whole receives its proper appearance and size, though portions should here and there have to be somewhat deformed and altered. The elevation figures demand also some change. All this requires more practice and discrimination than most other topographical work.

The reason why this apparently unnecessary reduction is undertaken, is the great expense of the engraving of the map, which is drawn on copper, and which, on the scale 1 : 50000, would be nearly four times as expensive as on the scale 1 : 100000; besides, it would take four times as long to complete it.

ENGRAVING AND PUBLISHING.

Before 1857 the map on the scale 1 : 100000 was kept secret. At first there were only hand-made copies of it, but in 1826 it was ordered that it should be engraved, the work to be done by officers of the topographical corps, who, after taking the "service oath," were to be responsible for the secrecy of the map during the engraving, as well as during and after the printing. It was engraved on copper, and, with the exception of names, by etching. When the government in 1857, on the recommendation of the chief of the corps, permitted the publication of the map, there were 20 of those sheets engraved by etching, which were, on account of the age of the concept-map, regarded as not fit to be published, while 11 were published after having been previously tested in the field.

The engraving of the later sheets is done with the graver by copper-engravers, some of whom are employed in the corps, and some work on contract. In this way 37 sheets have been engraved since 1857.

The Swedish general staff intends in future to use, instead of copper engraving, the Austrian Mariotte's Heliography method, which has been purchased by the Swedish government. Experiments with it on a large scale are at present in operation.

In accordance with a royal order of 1833, the Hermelin Atlas was transferred from the land-survey office to the topographical corps, with instructions that the net income from the sale of the maps should be used for compiling "lån" [5]maps on a scale of 1 : 200000. It had been the duty of the topographical corps since 1832 to compile as the military atlas was progressing, and with the use of the same as material, an atlas of the låns of Sweden, on the scale 1 : 200000, accompanied by statistical descriptions. Of this atlas maps of 10 låns have been published since 1841, comprising 15 sheets, all engraved on copper with the graver. As the designation of the irregularities of the ground makes a map expensive, and by many buyers is regarded as valueless, it was excluded on the last map of "Calmar lån," issued on two sheets in 1871.

In the following year the government ordered that the work on this atlas should be discontinued till further orders.

A general map on a smaller scale should properly be the last link of all the above-mentioned works, and the need of it had so frequently shown itself that it was not thought advisable to wait until the completion of the whole atlas. The general map of Sweden, on the scale of 1 : 1000000, has been in active preparation since 1865. It is to be published in three sheets, of which the southern has been obtainable since 1870 at the book-stores. The two other sheets are in process of preparation.

COST.

Let me refer, concerning the cost of the geodetic and topographical work executed in Sweden, to the attached table, which contains the total cost of these works, and also an account of the yearly expenses from 1858 to 1874, inclusive.

The same table shows that the yearly appropriation from 1869 to 1874, inclusive, has been 60,000 Swedish crowns, or $16,000. The appropriation for the present year is the same; but from and including the year 1876 it will be 75,000 Swedish crowns, or $20,000[6] approximately.

THE ECONOMY MAP ESTABLISHMENT OF SWEDEN.

This establishment, the main object of which is to obtain an accurate knowledge of the area of the kingdom and of the economic condition and distribution of this area, was established in 1859. The General Land-Survey Office has had the superintendence of it up to 1873, when it was placed under the direction of the chief of the topographical division of the general staff.

The Economy Map Establishment has ever since its organization been managed in two divisions: one for the southern and central parts of the country and one for "Norrbotten lån," which, comprising the northmost part of the country, makes a special map-work necessary on account of its vast extent and its slight cultivation. The division first mentioned prepares its concept maps on the scale 1 : 20000. In "Norrbotten lån," where the surveys have at the same time a topographical object, the scales 1 : 20000, 1 : 40000, and 1 : 50000 are used; the last, however, only in "Lappmarken."

Between 1860 and 1874, 26,850 square kilometers of Central Sweden have been surveyed and 70,800 square kilometers of Norrbotten lån. The maps of Southern and Central Sweden are published by the "harad"[7] on the scale 1 : 50000. There are already published maps of the whole of Upsal and Örebro lån, of some hårads of the Great Copperbergs and Stockholm lån, and of part of the province of East Gothland. Five "härad maps" of Norrbotten lån on the scale 1 : 100000 have been published.

Although the surveys for the maps are carried on by appropriations from the government, their publication, as far as concerns the southern and central parts of the country, depends upon applications made by "economy societies" or communities, who then pay the expenses.

The government appropriation for the coming year (1876) is 87,000 crowns, ($23,200[6],) of which 30,000 crowns ($8,000) are for Norrbotten.

Two officers of the general staff are appointed to direct the work of the Economy Map Establishment. The force consists besides of 19 cartographers and 11 persons who do the drawing, among whom are 8 ladies.

The work done by this establishment for the preparation of the skeleton map, on the scales 1 : 20000 or 1 : 40000 may be divided into—

a. Transferring of homestead-maps.—All recent land-surveyors' maps of homesteads, situated in a locality where an economy map is to be made, (which locality is decided on by the chief of the topographical division of the general staff with a view to the requirements of the topographical work,) are transferred to the scale 1 : 20000. Lake charts are also transferred when they can be procured. This work is done during the winter. County-surveyors' maps which are missing are looked up in the county-surveyors' offices of the låns or at private farm-owners', and are transferred where found.

b. The field-work.—The plats thus obtained are compared by the surveyor with the corresponding objects in the field, and such changes as have occurred since the survey of the plats, as newly-broken lands, additional and removed houses, drained lakes, morasses, and marshes, roads built or destroyed, &c., are ascertained and marked. Various objects which are not distinctly marked on the common land-survey maps, as dwelling-houses, forest-roads, foliage, pine-woods, orchards, &c., are located and sketched in, so that the map becomes a perfect plane-image of the ground, with its artificial and natural objects. For this work is used either the common plane-table, with index-ruler, or the stadia. Those homesteads of which no land-survey map can be obtained, as well as places near the coast of which no reliable lake chart exists, are surveyed on the scale either of 1 : 20000 or of 1 : 8000. In the latter case they are afterwards reduced to the scale 1 : 20000. In this survey the stadia is used after one or more base-lines have been first staked out and chained. Triangulation points, necessary for the putting together of the plats, are located on the map. The conventional signs for different objects are almost the same as those adopted for the topographical maps. The principal differences are that homestead limits are indicated, that dwelling-houses are colored red, cultivated lands yellow, meadow green, marsh and morass brown. These latter are, besides, ruled with broken parallel lines of india ink.

c. The putting together of the map.—In order to connect these revised and corrected copies and newly-surveyed maps satisfactorily, a secondary triangulation is needed, to furnish a sufficient number of base-points. This triangulation is, as stated before, executed by the topographical division of the general staff, as it is regarded necessary to have, if possible, at least three points determined within every 100 square kilometers.

The arrangement of the economy maps is made in conformity with that fixed for the topographical map of Sweden, in such a way that one sheet of this map on the scale 1 : 100000 includes twenty-five sheets of the economy map on the scale 1 : 20000, each representing an area of 105.82 square kilometers, and measuring 594^{mm} in length by 445^{mm} in width. For putting together the map, on a large table a net of rectangles is constructed of the size designed for the sheets. Within these rectangles the triangulation-points are plotted from their co-ordinates, calculated with reference to the sides of the said rectangles, after which the corresponding located triangulation-points on the homestead-plats are fastened with needles directly over the located points. In the intervals between the plats thus secured all the rest are fitted in the usual manner, so that they meet snug at the borders. When they are all fitted together properly they are fastened with mouth-glue, after which the map is cut into sheets. These sheets are now completed in what may be wanting in the drawing and by naming all the objects on them. Each sheet is

named after its most prominent place, and retains also the name of the topographical sheet on the scale 1 : 100000, within which it is situated.

d. Drawing up of descriptions.—All whole and fractional parishes on the sheet have their areas calculated and corrected : first, for the error caused by the shrinking of the sheet, and next for the inequality which arises between the total area of the parishes put together, and the area which the whole sheet should represent. Here it should be remarked that the stated area of 105.82 square kilometers on each sheet, which makes a part of the conical projection surface on which the triangulation net of the country is constructed, differs more or less in size at different degrees of latitude from the corresponding area on the ground, so that it must be reduced with the aid of a previously prepared reduction-table to the corresponding real area on the earth's surface. The areas of all entire homesteads and fractions of such, which are included on the sheet, are also calculated and corrected by the parish, so that the total area of the homesteads within each parish will be equal to the area of the same parish obtained in the manner above stated. The areas of the homesteads and parishes are computed partly with the circular planimeter and partly with the polar planimeter.

These statements are entered in the "härad descriptions," which contain besides the name and nature (frälsekrono or skatte) of the homesteads and localities, and for each homestead the areas of lots, orchards, cultivated fields, meadow, timbered and cleared lands, roads, sterile morasses, barren mountains, obstructions, lakes, water sources, &c., and notes on matters of special importance at each homestead.

The economy and topographical mapping of Lappmarken, in the lån of North Bothnia, on the scales 1 : 20000 and 1 : 50000, represents, for the most part, an entirely new survey of this part of the country, as the previously made land-survey maps are quite scarce. As bases for this survey and mapping, the positions of a large number of points in the southern part of Lappmarken were determined astronomically in 1860, 1861, and 1862, and a minute triangulation was executed in later years of the central and northern parts.

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Summary of expenses of the Swedish topographical atlas.

Year.	Appropriation per year.	Triangulation.	Astronomical location.	Field survey and leveling in various scales.	Map of Sweden, (engraving, paper, plates, and coloring.)	Skeleton-map works in the country.	The lån map work, (gross.)	Winter work.	The war archives.	Traveling for inspection.	Salaries to extra assistants.	Rent.	Sundry.	Total.
	Cr. öre.	*Cr. öre.*	*Cr. öre*	*Cr. öre.*	*Cr. öre.*	*Cr. öre.*	*Cr. öre.*	*Cr. öre.*	*Cr. öre.*	*Cr. öre*	*Cr. öre*	*Cr. öre*	*Cr. öre.*	*Cr. öre.*
1812 to 1857	...	93, 946 74	14, 223 89	318, 549 20	32, 845 22	42, 289 68	74, 242 29	28, 615 17	27, 066 93	16, 886 65	...	...	44, 309 75	692, 975 52
1858	27, 800	615 81	...	21, 564 74	510 00	...	1, 886 90	2, 643 01	1, 734 65	1, 758 99	...	...	5, 776 90	35, 491 00
1859	27, 800	...	...	17, 500 68	3, 457 01	...	6, 379 85	2, 548 32	4, 922 61	113 76	2, 750 00	2, 112 48	1, 090 00	40, 874 71
1860	27, 800	...	...	9, 570 64	7, 702 00	...	4, 867 12	120 00	2, 779 37	549 39	3, 085 01	1, 560 84	3, 586 63	33, 821 00
1861	53, 200	2, 844 93	...	13, 143 57	12, 099 75	...	1, 707 05	1, 311 17	2, 034 05	864 34	3, 200 00	2, 481 67	8, 960 44	48, 646 97
1862	53, 200	1, 509 73	...	24, 113 35	12, 021 34	...	1, 480 50	2, 649 19	2, 391 57	801 00	3, 200 00	2, 052 25	4, 737 69	54, 956 62
1863	53, 200	...	...	26, 778 65	11, 213 07	...	1, 395 00	6, 541 67	1, 313 39	986 54	6, 437 68	3, 251 12	1, 990 61	59, 907 73
1864	53, 200	4, 536 33	...	17, 938 13	12, 370 30	2, 983 01	872 06	6, 297 74	2, 480 96	956 27	4, 430 00	3, 267 57	3, 565 75	59, 698 11
1865	53, 200	5, 224 33	...	23, 852 80	13, 774 73	747 14	743 75	6, 569 33	2, 311 98	661 21	4, 110 00	3, 612 81	4, 068 58	65, 656 66
1866	53, 200	...	...	22, 918 57	15, 512 05	4, 277 54	1, 056 53	7, 352 32	3, 018 25	1, 259 93	4, 705 00	3, 248 28	1, 028 47	64, 376 64
1867	75, 000	6, 246 24	...	27, 893 23	15, 875 09	310 60	694 10	6, 763 98	1, 939 35	605 94	4, 912 50	3, 421 45	4, 311 25	72, 973 43
1868	75, 000	8, 904 06	...	15, 663 83	16, 231 96	1, 649 48	1, 576 18	3, 115 50	4, 491 79	798 41	6, 730 67	4, 095 41	2, 973 02	66, 230 31
1869	60, 000	9, 577 34	...	24, 262 17	11, 877 10	...	692 00	2, 714 32	2, 376 67	538 24	6, 982 50	4, 945 77	3, 252 81	67, 218 22
1870	60, 000	4, 413 95	...	18, 156 67	20, 949 86	3, 765 44	2, 323 75	2, 883 70	2, 036 41	525 25	4, 085 00	3, 636 19	5, 096 87	67, 870 09
1871	60, 000	2, 072 63	...	15, 842 74	19, 636 73	...	1, 364 15	3, 932 80	1, 902 65	566 94	3, 817 50	1, 677 15	5, 165 64	55, 978 93
1872	60, 000	4, 457 13	...	22, 011 28	17, 041 92	...	457 00	4, 772 50	1, 792 48	717 23	4, 783 33	2, 978 33	5, 098 76	64, 110 02
1873	60, 000	3, 162 23	...	17, 339 16	15, 222 35	2, 927 57	866 00	7, 250 72	2, 234 11	438 83	4, 457 50	6, 259 48	7, 970 54	68, 128 43
1874	60, 000	2, 761 84	...	16, 671 15	17, 737 29	2, 584 17	848 50	6, 377 35	...	312 30	5, 596 67	633 00	10, 361 67	63, 883 94
		150, 273 29	14, 223 89	653, 770 56	256, 074 77	61, 534 57	103, 432 43	102, 458 73	66, 827 22	28, 341 22	73, 283 36	49, 233 56	123, 345 37	1, 682, 799 03

1 Swedish crown = 26 85-100 cts. gold.

REMARKS.

1. That the total expenses for the year mostly exceed the appropriation proper depends upon the income from sale of maps, &c.
2. The expenses of the war archives are principally purchase of books, maps, instruments, and inventories, besides expenses above the ordinary appropriation.

NOTES AND EXPLANATIONS.

1. Sweden is divided into three principal parts, viz, Svêa-land, the central part Gotha-land, the southern, and Norr-land, the northern part of the country.

2. "The royal majesty" is an expression very commonly used for "the government," the state, the highest authority, or "the crown."

3. "Hemman" is a part of a parish, and may be translated by the word "homestead."

4. The Swedish word "Kartwerk" means both an atlas and an establishment for making maps.

5. The kingdom is divided into 25 lāns, each under the authority of a governor.

6. This estimate is given in gold. It is given in round numbers, as, according to close calculation, 1,000 Swedish crowns = $268½ gold.

7. "Härad" is a subdivision of the "lān."

8. Homesteads (hemman) are of three kinds, "frälse," "krono," and "skatte" hemman, which names indicate, respectively, tax-free, crown, (or government,) and tax-paying homesteads.

9. One Swedish crown (krona) is divided into one hundred parts called öre.

10. å, *ä* (or ā) and *ö* (or ō) are the three last letters in the Swedish alphabet, and are pronounced respectively as *o* in for, *a* in cast, blast, and *i* in first, bird.—[TRANSLATOR.]

§ 2. NOTES ON TOPOGRAPHICAL MAPS OF SWEDEN.

The area of Sweden is 170,101 square miles. For administrative purposes it is divided into three districts called "poiks;" these are subdivided into läns, which correspond to our counties, and the läns are divided into härads and söckens.

There have been sent to this office for examination an index-sheet, on which there is also a table of conventional signs, several sheets showing the state of the triangulation, surveys, and publication at different dates: one sheet of a general chart of Sweden on a scale of 1 : 1000000; forty-eight sheets of the topographical map of Sweden on a scale of 1 : 100000; thirteen län-charts on a scale of 1 : 200000; and two härad charts, one on the scale of 1 : 50000, and the other on that of 1 : 100000.

THE GENERAL CHART.

This is on a scale of 1 : 1000000. The projection is so made that the sheets can be joined together and mounted, making a single map. The lines representing the whole degrees of longitude (reckoned from Stockholm observatory) and of latitude are drawn, and the border is divided into 5′ spaces. The lower border is further divided into spaces representing the longitude east from Ferro. In this map are shown, by the usual conventional signs, the water-courses, lakes, cities, towns, villages, castles, railroads, post-roads, iron and copper mines, and boundary-lines of the civil divisions. The water is colored blue, and the boundary-lines are shaded in different colors. The names of the civil divisions are not printed on the map proper, but the läns are numbered by the Roman notation, and the härads by the Arabic, and the names corresponding to these numbers are printed on the side of the sheet. The relief is shown by hachures, and by printing the exact altitudes of various points on the map.

THE TOPOGRAPHICAL CHART.

The scale is 1:100000. This map is engraved on copper and is published in rectangular sheets, each of which represents an area of 59.4 by 40.5 kilometers. The rectangles are formed by drawing lines parallel and perpendicular to the meridian, which is 5° west of Stockholm. This is taken as the central meridian in the projection of all the sheets. The rows of rectangles are numbered from the central meridian to the

east and west, and from the north to the south, so that the position of the sheet is shown by printing on it the number of the row east or west in Roman numbers, that of the row from the north in Arabic numbers; *e. g.*, "IV E. 31." The lines representing the parallels and meridians at distances of 10′ apart are drawn, and the border is further divided into 1′ spaces. Scales of meters and Swedish miles are given. The sheets, which are clear and handsome, give a very detailed representation of the natural and artificial features of the country, showing by appropriate topographical signs the water-courses, canals, lakes, ponds, marshes, railroads, post-roads, common roads, bye-roads, stone bridges, wooden bridges, light-houses, anchoring-grounds, cities, towns, villages, churches, castles, mills, farm-houses, forests, woods; silver, copper, and iron mines, telegraph-lines, and the boundary-lines of the various divisions. The water and boundary lines are colored. The relief is shown by hachures, and by writing the heights of the prominent elevations, and of numerous other points along the roads and streams. On the sea-coast there are also hydrographic charts, the depths being given for a distance of about one Swedish mile (6.65 English miles) from the shore. The curves of 10, 20, and in some places of 25 and 30 feet depth, are drawn. Beyond these the depths are given in fathoms.

HÄRAD PLANS.

These are colored lithographs, and appear to be made for cadastral purposes, as property boundaries and the limits of cultivated, waste, and meadow-lands are shown; and each sheet contains a table giving the areas of the different classes of land and of the water in each söcken. The relief is not indicated nor are soundings given; otherwise the plans show about the same features as the topographical charts.

LÄN MAPS.

These maps, on a scale of 1 : 200,000, are engraved on copper. The water and boundary lines are colored. The härads are designated by Roman numerals, and the corresponding names are found at the side of the sheet. The principal features represented are the water-courses, lakes, marshes, cities, towns, villages, manor-houses, farm-houses, court-houses, mills, mines, railroads, turnpikes and common roads, canals, light-houses, triangulation-points, and anchorage-grounds. The relief is shown by hachures and by the written altitudes of a few points. At the sides of the sheets are engraved plans of the principal towns and the country immediately surrounding them on a scale of 1 : 20,000. An index to the conventional signs employed is printed on each sheet.

Compiled by Lieut. P. M. Price, United States Engineers.

§ 3. Notes on Norwegian Maps.

Norway has an area of about 123,000 square miles. For administration purposes it is divided into five stiften or provinces, which are subdivided into 17 amts or counties. The smaller subdivisions in order of size are fogdeir, praestegjelds or parishes, and anneks. Eight distinct series of maps and charts are published. Of these there have been sent to this office for examination seven index and progress sheets, two of which show the primary and secondary triangles; six sheets of the general chart of Southern Norway on a scale of 1 : 400000; 25 sheets of the amt charts on a scale of 1 : 200000; 12 sheets of the general topograph-

ical charts on a scale of 1 : 100000; five sheets of a general chart of the Norwegian coast on scales of 1 : 350000 and 1 : 800000; 13 sheets of a second general chart of the coast on a scale of 1 : 200000; 11 sheets of a coast-chart showing, by colors, the character of the bottom, on scales of 1 : 100000 and 1 : 200000; 12 sheets of a special chart of the coast on a scale of 1 : 100000; and 18 sheets of a second special chart on a scale of 1 : 50000.

Longitude on all the charts is reckoned from Christiana observatory, but the longitudes from Paris, Greenwich, and Fërro are shown on the borders of most of the charts.

GENERAL CHART OF SOUTHERN NORWAY.

The scale is 1 : 400000. The chart is published in rectangles, each of which represents an area of 16 by 13 Norwegian miles, (one Norwegian mile equal to 7.017 English miles.) The sheets are lithographs. The water is in blue, the roads and towns are in red, and the boundary-lines and contours in black. These are about the only features represented. The chart is published in two styles, the relief being shown in one series by contour-lines and by numbers giving the altitudes of the most prominent elevations, and in the other brown shading is employed in addition to the above methods.

TOPOGRAPHICAL CHART.

The scale is 1 : 100000. This chart is also lithographed and published in rectangles, each of which represents an area of 4 by 3 Norwegian miles. The rectangles are numbered, and are also named from the principal town contained in each. The meridians and parallels at distances of 10′ apart are drawn, and the border is divided into 1′ spaces. Scales of Norwegian and geographical miles and of feet and meters are given. The names of the adjoining rectangles are printed on the margin at the four sides.

The sheets are accompanied by an index-chart, which also contains a table of the topographical signs employed. The charts are quite detailed, and in general give a clear representation of the country, although the large number of names written in the more thickly settled portions somewhat diminishes the distinctness. The charts show by appropriate topographical signs the boundary-lines of the various civil divisions, the cities, towns, villages, churches, manor and farm houses, fisheries, water, saw, and wind mills; iron, copper, silver, and glass works; manufactories, brick-kilns, drill-grounds, trigonometrical points, post and common roads, railroads, telegraph-lines, water-courses, lakes, marshes, canals, light-houses, buoys, and anchoring-grounds. The water is colored blue. The relief is shown by horizontal curves 100 feet apart in vertical distance, and by numbers giving the absolute altitudes of various points, and in addition to these methods the hills are shaded in brown. The depths along the sea-coast are given in fathoms.

AMT CHARTS.

The scale is 1 : 200000. Some of these charts are copper engravings, others lithographs.

The sheets are not of uniform size, one amt being in some cases represented on a single sheet, and in others on two or more. They show about the same features as the topographical charts, but the names are not given with so much detail. The relief is shown by shaded con-

SWEDEN. PART OF "I. Ö. 41."

tours. Plans of the larger cities, on a scale of 1 : 20000, are drawn at the sides of the sheets inside of the border.

Each chart has printed upon it a table of altitudes, giving the heights of prominent points, lakes, &c.; a table giving the areas in Norwegian miles of the civil divisions; tables giving the parts of which the various civil and judicial districts are composed; and a table of conventional signs.

SEA-COAST CHARTS.

There are five series of these:

1st. These are charts of the sea-banks along the Norwegian coast, on scales of 1 : 100000 and 1 : 200000. The form of the bottom is shown by contour lines 10 feet apart, and the character of the bottom by different colors and signs, indicating fine sand, sand, gravel, clay, stones, rock, &c. The contours and colors are not carried to the shore, but extend from a distance of ¼ to 1 Norwegian mile from the shore outwards. Depths from these points to the shore and intermediate depths are shown by figures. The land is indicated by parallel black lines drawn very close to each other, and the only topographical features shown are the towns and hamlets on the sea-shore, a few of the prominent hills, and the light-houses. A representation of the card of the mariners' compass, showing the directions of the 32 points, reckoned from the magnetic meridian, is given on each chart.

A sheet showing the profiles of the bottom between various points accompanies this series.

2d. The remaining four series of charts consist of two series, A and B, of general charts, the first on scales of 1 : 350000 and 1 : 800000, the second on a scale of 1 : 200000; and of two series, A and B, of special charts, the first on a scale of 1 : 100000; and the second on a scale of 1 : 50000. The two last series had not been completed in 1872. These are all sailing-charts, and present the same general features, differing from each other mainly in greater clearness and amount of detail of those on the larger scales, so that a general description will apply to all. A detailed description of each series would necessitate describing separately nearly every sheet, as a uniform system of publication does not seem to have been adopted, even for charts of the same series. The larger number of the charts are engraved, the rest are lithographs.

In general the topographical features of but a narrow strip along the shore are represented, and on many of the charts nothing is drawn but the shore-line, the towns and hamlets on it, and some of the prominent hills, and light-houses. The soundings are given in fathoms. The character of the bottom is indicated by letters, and the positions of buoys, sunken rocks, and shoals are shown by conventional signs. On most of the sheets elevations of the light-houses are drawn, and on many of them sketches showing the appearance of the shore from the sea. The deviation of the needle at various points is given, and at most of them a diagram is drawn, showing the directions of the 32 points of the compass, taking into account this deviation.

Circles are drawn with the light-houses as centers, showing the limits of visibility of the light, and the characters of the lights are either written along the circumferences of these circles, or on some other part of the sheet. On many of the special charts sailing-directions are written, and the compass-bearings between different points given.

Compiled by Lieut. P. M. Price, Corps of Engineers.

CHAPTER IX.

§ 1. Notes on Topographical Maps of Belgium.

Two sheets furnished for examination. Scale of the published maps, 1 : 40000; size of sheets, $31\frac{1}{8}$ by $19\frac{1}{2}$ inches; area represented on each sheet, 32,000 meters east and west by 20,000 meters north and south. The work is engraved on copper. Meridians and parallels are drawn for every 5′ of arc, and the exact latitude and longitude of the corners (N. E., N. W., S. E., S. W.) of the area represented are given on each sheet. The sheets are numbered and named at top, the name being that of the most prominent town or village represented. The number serves to locate the sheet in connection with the adjoining sheets, as indicated by a diagram giving the numbers of the maps of the adjacent territory.

Meter, league, and marine-league scales are given at bottom of the sheet. Contours are drawn for every 5^{m} of elevation, and the heights of prominent points are given in meters.

Railroads, common roads, by-ways, and paths, streams, cultivation, forests, woods, quarries, bridges, and isolated houses are indicated.

The positions of triangulation-stations and bench-marks are also given.

The nomenclature is detailed, giving names of roads and railroads, of streams, villages, and detached houses. Water is indicated by lines of shading, not by colors. Numerous conventional signs are used to indicate trees, forests, cultivation, battle-fields, &c.

Authorities.—Two Belgian maps.

Compiled by H. M. Adams, captain of engineers.

CHAPTER X.

§ 1.—Notes on Russian Surveys.

While Russia has begun or executed grandiose geodetic works, such as Struve's arc of the meridian from the North Sea to the Danube, and her part of the great arc of the parallel of 52° north latitude, extending from Valentia, in Ireland, to Orsk, in Russia, and while she has executed primary triangulations covering large areas in the western governments of Russia, in Poland, and, more recently, in the country of the Cossacks of the Don, the Caucasus, and the valley of the Volga, she does not appear to have carried detailed and precise topographical work, based on secondary and tertiary triangulations, over large areas.

Much of the geodetic work, both in the measurements of angles and of bases, is of the first class.

In 1819 the great imperial surveys of the western governments of Russia were begun; that is, the survey of each government or province. First, each was to be covered by a trigonometrical net, so as to give two or three trigonometrical points on each plane-table sheet, and these were the bases for a geometrical net. The surveys of this period can be divided into three classes:

Topographical, made with all available instrumental aid.

Partly instrumental surveys, instruments not always being used.

Ocular surveys, or reconnaissances.

1. *Topographical surveys* were begun on a scale of 250 sagenes to an English inch, or 1:21,000. In these surveys all roads, streams, and villages were located by instruments; long lines were chained, short ones paced.

2. *Partly instrumental surveys* determined with the plane-table only principal rivers, roads, &c., the compass being used for others, with chaining for long distances and pacing for shorter ones. The government of Minsk was surveyed in this way and parts of Siberia, but the latter had no triangulation and few points fixed astronomically.

3. *Ocular surveys.*—These were mainly executed in European Turkey, on marches, the odometer, small plane-table, and compass being used, and many distances were estimated.

From 1819 to 1829 the survey of the government of Vilno was carried on by General Tenner, on a scale of 1:21,000, (one verst = an inch,) giving 658 sheets, based on a trigonometrical net. Its area was 57,432 square versts, (verst = 3,500 English feet.)

Trigonometrical points were plotted on plane-table sheets of 20 inches, on a side; scale, 1:21,000. Mountains were represented by Lehmann's method.

The cost varied from 7 rubles 89 kopecks to 3 rubles 86 kopecks per square verst, each surveyor averaging 140 versts per year. One plane-table sheet included 100 square versts.

The survey of the government of Grodno was begun in 1837 by Colonel Rokassovski, on a scale of 1:16,800. Trigonometrical points, whenever they fell on a sheet, were plotted on it. Plans of cities on a scale of 1:8,400. Plane-table sheets 25 inches square contained 100 square versts, and were to be finished in one year by one surveyor.

The survey of the government of Minsk was a partly instrumental survey, under General Fittinghoff, and is of 256 sheets, on a scale of 1:21,000.

As Minsk is covered by forests, swamps, and moors, a precise instrumental survey was scarcely practicable. The guiding points of the triangulation were few. Lines were run along roads, and points on each side to the distance of a verst were located. The survey was completed in 1840, and covered 86,647 square versts.

Similar surveys were executed in South Russia, Bessarabia, Orenburg, Western Siberia, and New Finland.

Ocular surveys were carried on, in the manner previously described, in Moldavia, Wallachia, and Bulgaria, the scale being 1:84,000, and the numbers of sheet, respectively, 41, 25, and 10.

The following table indicates the extent of surveys, a star indicating those provinces in which the heights of mountains were measured; scale of sheets, 1:21,000.

Government or province.	Year.	No. of square versts.	No. of sheets.
Witepsk	1845–1850	39, 708	128
Kiev*	1847–1849	44, 730	143
Smolensk	1848–1850	48, 994	159
Mohilev	1848–1850	41, 987	136
Cherson*	1850–1852	62, 209	242
Kaluga	1851–1852	27, 143	137
Moscow, (part)*	1852–1853	20, 314	49
Ekaterinoslav*	1853–1856	59, 485	259
Tula*	1853–1854	26, 956	109
Tchernigov*	1854–1856	46, 042	198
Liefland	1855–1857	40, 243	196
Tauride, (north part)*	1855–1855	31, 474	151
Pultava*	1857–1859	43, 686	140
Charkov*	1857–1859	47, 835	158
Estland*	1858–1859	17, 351	95
Orlov*	1860–1862	41, 074	186
Kingdom of Poland*	1860–1869	111, 860	474
Kursk*	1860–1862	40, 718	176
Novgorod*	1860–1865	102, 703	402
Voronez*	1860–1866	57, 881	188
Saratov*	1863–1867	73, 608	190
Kazan	1867 cont'd	....	......
Kostroma	1868 cont'd.	....	......

Total surveyed, Kazan and Kostroma omitted, 1,027,100 square versts; total surveyed, Minsk and Crimean Peninsula included, 1,136,095 square versts.

When the scale 1:21,000 was adopted, instructions were given in reference to the survey of the interior governments of European Russia. The survey was to be based on points astronomically determined. Chained lines were to be run with compass from one astronomical station to another along the open roads. All important points on either side were to be observed, making cuts through the forests when necessary. Three sides of an astronomical triangle were thus surveyed; but these sides averaged about 50 versts in length, giving large interior areas, without any standard points. Accordingly, other lines, running from a vertex of a triangle to the middle of an opposite side, were surveyed in a similar manner. Such lines furnished the standard points on which the plane-table sheets were based.

At first maps were kept secret, but in 1857 this was abandoned; and the following table gives a list of maps for sale at 50 kopecks per sheet.

Government.	No. of sheets.	Government.	No. of sheets.
Minsk	41	Kaluga	18
Grodno	21	Witepsk	25
Podole	24	Smolensk	28
Don Cossacks	63	Tula	17
Kiev	25	Tchernigov	26
Cherson	32	Ekaterinoslav	23
Courland	19	Tauride	34
Bessarabia	29	Liefland	26
Moscow	40	Esthonia	14
Kowno	22	Pultava	24
Vilno	23	Charkov	28
Mohilev	25		

In 1866 the military topographical corps was reorganized and a programme of instructions adopted. Its organization is 6 generals, 33 majors, lieutenant-colonels, and colonels; 150 cornets, lieutenants, and captains; 170 classed topographers; 236 topographers of sergeant's rank; 42 apprentices.

Since 1870, 124,000 rubles have been appropriated annually for geodetic and astronomic work, and 46,000 rubles for publication of maps. Operations in provinces and districts are paid from local funds.

In the surveys, between 1861 and 1871, of Kazan and Kostroma, the determination of heights in topographical work seems first to have been introduced.

Several important maps have been recently undertaken, among which may be mentioned:

Special map of European Russia in 152 sheets, and on a scale of 1:210,000, of which 62 sheets had been engraved in 1872.

Map of kingdom of Poland, in 53 sheets, to have been completed in 1870.

Map of Turkey, on scale of 1:210,000; begun in 1867, and to be a chromolithograph.

Various modern methods for the reproduction of maps have been experimented with, and recently Colonel Stubensdorf, director of the chartographical department, after a careful examination of the processes of helio-engraving of Colonel Arét and M. Mariotté, purchased the secret of the latter for the Russian government, and a special body of sworn persons was sent to Vienna to learn the process.

Compiled from translation by Dr. Henry Kalussowski of Historical Sketch of the Corps of Military Topographers from 1822 to 1872, St. Petersburg, 1872, by Maj. C. B. Comstock, Corps of Engineers.

APPENDIX I I.

ANNUAL REPORT OF MR. CLARENCE KING, GEOLOGIST, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

GEOLOGICAL EXPLORATION OF THE FORTIETH PARALLEL, FROM SIERRA NEVADA TO THE EASTERN SLOPE OF THE ROCKY MOUNTAINS.

U. S. GEOLOGICAL EXPLORATION OF THE 40TH PARALLEL,
Newport, R. I., August 29, 1876.

GENERAL: I have the honor to present the following brief annual report:

During the entire year, from June 30, 1875, to June 30, 1876, the corps of the exploration of the Fortieth Parallel have been in office, devoted to the final preparation of the reports, together with illustrations and atlas, and with the following result:

Volume IV consists of the report of Dr. Ferdinand Zirkel on *Microscopic Petrography*, with illustrations of thin sections of crystalline rocks viewed by transmitted light; report of F. B. Meek on *Invertebrate Paleontology*, illustrated by lithographic plates of molluskan fossils; report of Messrs. Hall and Whitfield on *Paleozoic Mollusks*, with lithographic illustration; and report of Robert Ridgway on zoological ob-

servations made during the survey. These several reports, together constituting a quarto volume of about 900 pages of print, have been completed, the illustrations have been engraved, corrected, and all printed, and the manuscript ordered to be printed by the Honorable the Secretary of War.

Volume II, embracing the joint geological results of the geologist in charge and the two geological assistants, Messrs. S. F. Emmons and Arnold Hague, has been completed, with the exception of a small portion of the final chapter, and the illustrations to accompany it are drawn upon stone, finally corrected, and printed.

Volume I, necessarily the latest of the series, embodies a general and systematic review of the results of the expedition, and, in consequence, could not be prepared until after the completion of the other special reports. It is, however, half done, and will be ready for the printer before Volume II can possibly be printed. The illustrations of Volume I, including a series of geological landscapes, a series of analytical geological maps, and diagrams illustrating orography, are all engraved upon stone, corrected, printed, and ready for publication.

Arrangements are made by which Volume IV will be immediately undertaken, and the whole series will go on hereafter uninterruptedly; and if there are no unforeseen delays they should all be done by the 1st of January.

The general atlas, embracing a general sketch-map of the mountains within the United States limits and west of the one hundred and fourth meridian; ten topographical sheets, covering the area of the Fortieth Parallel Exploration; ten companion geological sheets, each sheet of the same geological area as the corresponding topographical one; and, finally, two sheets upon which are shown two geological sections, each drawn from the one hundred and fourth to the one hundred and twentieth meridian, through the belt of the Fortieth Parallel work. These two sections, each of about 800 miles long, are the result of actual field-observation, and are among the longest sections that have ever been made in the world. The atlas has all been engraved, printed, and prepared, and is ready to be issued as soon as the volumes can be printed.

The work of the exploration is virtually over. Volumes III and V have already been issued, and there only remains the preparation of the unwritten part of the other volumes of the series, and their issue from the press.

Very respectfully, your obedient servant,

CLARENCE KING,
Geologist in Charge.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

APPENDIX J J.

ANNUAL REPORT OF LIEUTENANT GEORGE M. WHEELER, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

GEOGRAPHICAL SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN, IN CALIFORNIA, NEVADA, UTAH, COLORADO, WYOMING, NEW MEXICO, ARIZONA, AND MONTANA.

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UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., June 30, 1876.

SIR: I have the honor to submit the following report upon geographical surveys west of the one hundredth meridian for the fiscal year ending June 30, 1876:

The States and Territories of California, Nevada, Utah, Colorado, Wyoming, New Mexico, Arizona, and Montana, have each been chosen as fields of operation for the different expeditions engaged during the years 1869, 1871, 1872, 1873, 1874, and 1875.

SUMMARY OF FIELD AND OFFICE WORK.

At the close of the last fiscal year, the parties for field-work were actively employed and were commanded as stated in my annual report for that year.

The parties of California section disbanded at Caliente, the present terminus of the Southern Pacific Railroad, in November, 1875, a number of the officers and assistants repairing to Washington, while Lieutenant Whipple traveled southward to Los Angeles in charge of the transportation and supplies. Lieutenant Bergland's party reached Los Angeles on return from the first trip October 4, 1875, and departed again for the field in the southern portion of the valley of the Colorado River on February 13, 1876, and continued the examination of the river southward as far as Pilot Knob. Returning, he crossed the Desert and Coast ranges to Los Angeles, reaching that point May 7, 1876, where, his party having disbanded, the operations of this section of the survey were concluded for the year.

The parties of the Colorado section reached West Las Animas November 25, and proceeded immediately to conclude the operations of the field-season.

The officers on duty with the survey were employed during office-season as follows: First Lieut. W. L. Marshall, Corps of Engineers, in charge of field astronomical and meteorological computations, preparation of meteorological portion of Volume II, survey reports, executive report of field operations for past season, and detailed supervision of a portion of topographical plottings and reductions.

First Lieut. Eric Bergland, Corps of Engineers, in charge of temporary office at Los Angeles, Cal., for plotting and reduction of the topographical and meteorological data derived from the operations of special party for determining feasibility of diverting the Colorado River for purposes of irrigation.

First Lieut. W. L. Carpenter, Ninth Infantry, preparation of reports upon natural-history subjects; examination and disposition of specimens; executive report.

First Lieut. Rogers Birnie, jr., Thirteenth Infantry, assisting Lieutenant Marshall upon field astronomical and geodetic computations, and in immediate charge of topographical room.

First Lieut. C. C. Morrison, Sixth Cavalry, in charge of topographical work, (until relieved by Lieutenant Macomb, April 24, 1876,) special charge of instruments and instrument record, preparing tables of distances, executive report.

First Lieut. C. W. Whipple, Ordnance Corps, in charge of draughting work until relieved.

Second Lieut. M. M. Macomb, Fourth Artillery, in charge of draughting work since April 24, 1876, relieving Lieutenant Morrison.

Acting Assistant Surgeon H. C. Yarrow, United States Army, superintending publication of Volume V, (zoölogy,) examination and classification of collections in natural history, report of operations special field party.

Acting Assistant Surgeon J. T. Rothrock, United States Army, examination and classification of botanical collections, preparation of report special field party, preparation of MSS. for Volume VI, (botany.)

Hospital Steward T. V. Brown, United States Army, meteorological computations.

Dr. F. Kampf, astronomical observer, in computations for latitudes and longitudes. Messrs. George H. Birnie, F. Carpenter, F. A. Clark, W. A. Cowles, Anton Karl, F. O. Maxson, L. Nell, J. C. Spiller, and G. Thompson, (topographers,) reduction and plotting of field-notes. George M. Dunn, F. M. Lee, and William C. Niblack, and Privates Looram and Kirkpatrick, Battalion of Engineers, (barometric recorders,) in computation of field observations. Jules Marcou, A. R. Conkling, and D. A. Joy, (geologists,) preparation of reports. Dr. O. Loew (mineralogist and chemist,) analysis of collections and preparation of reports. H. W. Henshaw, (ornithologist,) identification and classification of collections and reports thereon, and assisting in publication of Volume V. Sereno Watson, (botanist,) and F. W. Putnam, (ethnologist,) examination of collections, and reports thereon. Charles Herman, J. C. Lang, E. Mahlo, and J. E. Weyss, (draughtsmen,) preparation of maps for publication. F. Klett, George M. Lockwood, and J. D. McChesney, correspondence and records, money and property accounts, reports, returns, distribution of reports and maps, &c., &c.

A general summary of the more prominent features of field and office operations is given below.

FIELD.

Sextant latitude-stations	102
Bases measured	6
Triangles about bases measured	50
Main t iangulation-stations occupied	111
Secondary triangulation-stations occupied	273
Three-point stations occupied	436
Camps made	825
Miles meandered	9, 463. 3
Miles traversed, not meandered	4, 799. 9
Stations on meanders	835
Magnetic variations observed	222
Monuments built	237
Cistern-barometer stations occupied	707
Aneroid stations occupied	5,553

Mining camps visited	22
Mineral and thermal springs noted	21
Geological and mineralogical specimens collected	380
Paleontological specimens collected	107
Botanical specimens (species) collected	350
Mammals, specimens collected	90
Birds, specimens collected	710
Other ornithological specimens collected	57
Reptiles, lots collected	67
Fishes, lots collected	29
Insects, lots collected	325
Shells, lots collected	12
Crustacea, lots collected	11
Radiates, lots collected	5
Ethnological specimens collected	363

OFFICE.

Astronomical positions computed	102
Stations adjusted by method of least squares	158
Triangles computed	644
Distances computed	1,288
Latitudes and longitudes computed	293
Azimuths computed	586
Sheets plotted 1 inch to 2 miles	9
Special sheets plotted, (various scales)	13
Cistern-barometer altitudes computed	930
Aneroid-barometer altitudes computed	5,013
Atlas maps, (1 inch to 2 miles,) published	1
Atlas maps, (1 inch to 4 miles,) published	3
Atlas maps, (1 inch to 8 miles)	3
Alas maps, (1 inch to 4 miles,) nearly ready for publication	5
Atlas maps, (1 inch to 4 miles,) partially completed	4
Reports published	3
Reports distributed	1,951
Reports in course of publication	1
Maps distributed	3,240

Personnel 1875–'76.

	Time employed.
OFFICERS, ACTING ASSISTANT SURGEONS, ETC.	
First Lieut. George M. Wheeler, Corps of Engineers, in charge	The whole year.
First Lieut. William L. Marshall, Corps of Engineers	Do.
First Lieut. Eric Bergland, Corps of Engineers	May 21, 1875, to end of year.
First Lieut. W. L. Carpenter, Ninth Infantry	May 22, 1875, to May 1, 1876.
First Lieut. Rogers Birnie, jr., Thirteenth Infantry	The whole year.
First Lieut. Charles C. Morrison, Sixth Cavalry	Do.
First Lieut. C. W. Whipple, Ordnance Corps	July 1, 1875, to January 15, 1876.
Second Lieut. M. M. Macomb, Fourth Artillery	April 24, 1876, to end of year.
Acting Assistant Surgeon H. C. Yarrow, (zoölogist)	July 1, 1875, to January 1, 1876.
Acting Assistant Surgeon J. T. Rothrock, (botanist)	July 1, 1875, to June 1, 1876.
Hospital Steward T. V. Brown, (recorder and computer)	July 1, 1875, to November 22, 1875.
ENLISTED MEN.	
First-class privates. John F. Kirkpatrick and William Looram, Company C, Battalion of Engineers, (barometric recorders.)	
Sergeant Eugene Farnum, Company G, Twelfth Infantry, and seven enlisted men, Company G, Twelfth Infantry.	
ASSISTANT ENGINEERS.	
Dr. F. Kampf, astronomer	The whole year.
George H. Birnie, topographer	Do.
Frank Carpenter, topographer	Do.
F. A. Clark, topographer	Do.
W. A Cowles, topographer	Do.
F. O. Maxson, topographer	Do.
Louis Nell, topographer	Do.
J. C. Spiller, topographer	Do.
Gilbert Thompson, topographer	Do.
HYPSOMETRIC RECORDERS.	
George M. Dunn	The whole year.
F. M. Lee	Do.
William C. Niblack	July 1, 1875, to November 30, 1875.
GEOLOGISTS.	
A. R. Conkling	The whole year.
Jules Marcou	July 1 to 31, October 1 to Dec. 31, 1875.
Douglas A. Joy	July 1, 1875, to November 30, 1875.
MINERALOGIST AND CHEMIST.	
Dr. Oscar Loew	July 1, 1875, to June 1, 1876.
COLLECTOR IN ZOÖLOGY.	
H. W. Henshaw, (ornithologist)	The whole year.
ETHNOLOGIST.	
F. W. Putnam	December 20, 1875, to close of year.
DRAUGHTSMEN.	
Charles Herman	The whole year.
J. C. Lang	Do.
Emil Mahlo	April 1st to close of year.
John E. Weyss	The whole year.
CLERICAL.	
Francis Klett	The whole year.
George M. Lockwood	Do.
J. D. McChesney	Do.

The gentlemen named in my last annual report have continued to extend cheerful assistance in the completion of results to the point of final publication in the natural-history branch, and I take this occasion to tender to them a merited recognition of their kindness.

The officers of the supply departments of the Army and of the military departments, districts, and posts touched by the different parties of the survey, have extended valuable assistance.

ASTRONOMICAL.

In this branch of the survey no work was accomplished during the year at main stations, since a large number of these had been occupied in former years, and measured and developed bases in the immediate vicinity of those bordering on the fields of survey had been completed. The usual observations for latitude at selected points along the routes of travel were made by the officers in charge of parties, and the results therefrom are given in a tabulated statement, as well as those of prior years. It was found impracticable to complete the dome and middle room of the observatory at Ogden for want of time and means. The telegraph lines southward from Santa Fé having reached Mesilla, New Mexico, and that west from San Antonio, Texas, Fort Stockton, it is improbable that during the fiscal year El Paso will have been connected both north and east, and further work accomplished in the direction of making a circuit from that point in the vicinity of the thirty-second parallel to San Diego. No further steps have been taken in the direction of securing sites for more or less permanent field observatories, but my recommendations of the past year are renewed.

Herewith is given the latitude of points determined by parties of the expeditions during several years and not elsewhere published.

GEOGRAPHICAL POSITIONS.

Sextant and transit for time; sextant for latitude; telegraphic time-signals for difference of longitude.

Year.	Station.	Atlas-sheet No.	Object observed.	Longitude west from Greenwich.	Latitude.	Altitude.	Variation of the needle, E.	Observer.	Computer.	Remarks.
				° ′ ″	° ′ ″	*Feet.*	° ′ ″			
1869	Camp Halleck, Nev	40	Sun Polaris β Scorpii α Scorpii	115 19 34.05	40 48 34.05	5789.7	16 21 24	Lieut. Wheeler Maj. Roberts	Lieut. Wheeler Maj. Roberts	
1869	Camp Ruby, Nev	49	Sun α Aquilæ Polaris α Ophiuchi	115 31 06.75	40 03 38.63	6152.6	17 09 04	Lieut. Wheeler Lieut. Lockwood Maj. Roberts	Lieut. Wheeler Maj. Roberts Dr. F. Kampf	
1872	Deep Creek, Utah	49	Sun Polaris α Aquilæ α Bootis	113 57 16.05	40 06 01.71	5236.6	....	Lieut. Hoxie E. P. Austin	Lieut. Marshall	
1869	Elko, Nev	40	Sun Polaris β Scorpii α Aquilæ	115 45 37.20	40 49 38.44	5148.4	17 35 03	Lieut. Wheeler Maj. Roberts	Lieut. Wheeler Maj. Roberts Dr. F. Kampf	
1872	Fillmore, Utah	59	Sun Polaris ε Pegasi α Bootis	112 16 54.93	38 57 14.94	....	16 15 00	Lieut. Hoxie Lieut. Wheeler E. P. Austin	Lieut. Marshall E. P. Austin	Camp three miles east of; on Chalk Creek.
1869	Hamilton, Nev	49	Sun Polaris Aquilæ α Aquilæ	115 25 58.38	39 15 48.87	7601.3	16 43 29	Lieut. Wheeler Maj. Roberts	Lieut. Wheeler Maj. Roberts	
1872	Kanab, Utah	67	Sun Polaris α Cygni α Tauri	112 31 39.00	37 02 25.43	4909.0	14 23 00	Lieut. Marshall E. P. Austin	Lieut. Marshall	Monument in square; front of bishop's residence.
1869	Monte Christo Mill, Nev.	49	Sun	115 34 49.20	39 13 16.83	7596.0	17 05 06	Lieut. Wheeler Maj. Roberts	Lieut Wheeler Maj. Roberts Dr. F. Kampf	
1869	Peko, Nev	40	Sun Polaris	115 30 14.50	40 55 46.35	5180.0	....	Lieut. Wheeler Maj. Roberts	Lieut. Wheeler Maj. Roberts Dr. F. Kampf	
1872	Pipe Springs, Ariz	67	Sun Polaris α Lyræ α Cygni	112 42 57.00	36 51 36.34	5397.2	....	Lieut Marshall E. P. Austin	Lieut. Marshall	Camp near.

1872–73	Provo, Utah	50	Sun Polaris α Cygni α Lyræ α Bootis α Virginis Jupiter	112 40 27.00	40 13 47.84	4567.3	....	Lieut. Hoxie J. H. Clark	Lieut. Hoxie J. H. Clark	Old Camp Rawlins; longitude determined by Lieut. Hoxie, 1873; latitude by Lieut. Marshall, 1872.
1873	Richfield, Utah	59	α Herculis Sun Polaris α Serpentis α Lyræ α Bootis α Aquilæ α Ophiuchi	112 02 27.00	38 46 11.40	5282.6	....	Lieut. Hoxie J. H. Clark	Lieut. Hoxie J. H. Clark	
1872	Toquerville, Utah	67	Sun Polaris	113 16 20.09	37 15 19.88	....	....	Lieut. Wheeler Lieut. Marshall E. P. Austin	Lieut. Marshall	Barometricrecords lost.

Geographical positions by measurement from or by trigonometrical connection with main astronomical points.

Year.	Station.	Atlas-sheet No.	Connected with astronomical station at—	Longitude.	Latitude.	Altitude above sea-level.	Variation of needle, E.	Connection made by—	Remarks.
				° ′ ″	° ′ ″	Feet.			
1872	Fort Cameron, Utah	59	Beaver, Utah	111 44 00.31	38 16 53.34	6057.7	....	Louis Nell	Difference in longitude and latitude determined by triangulation in 1872. At this time no flag-staff had been erected, and the object fixed was a building, the only one then in course of construction.
1873	Camp Douglas, Utah, (sun-dial)	41	Salt Lake City, Utah	111 50 13.92	40 45 47.47	5024.3	....	G. Thompson	By chaining from monument in Mormon Observatory, Temple square, Salt Lake City.
1873	Camp Douglas, (old flag-staff)	41	......do	111 50 14.07	40 45 47.58	....	....	G. Thompson	By chaining; old flag-staff since removed, but stump left standing as bench-mark.
1873	Fort Ellis, Montana	24	Bozeman, Montana	110 59 49.27	45 40 08.00	....	....	....	Approximate difference between astronomical observing pier and fort, taken from Land-Office plats. The position of the monument as located by J. H. Clark and the center of fort as given by Land-Office assumed as position of flag-staff.
1873	Fort Fred. Steele, Wyo., (flag-staff)	43	Fort Fred Steele, Wyo	106 56 54.27	41 46 50.63	....	....	J. E. Weyss	Difference between monument and flag-staff determined from plats and measurements by J. E. Weyss, and are given as approximate.
1873	Fort Sanders, Wyo	43	Laramie, Wyo	105 36 07.66	41 17 26.89	....	....	J. E. Weyss	

GEOGRAPHICAL POSITIONS.—*From sextant-observations in the field, for latitude and time.*

Year.	Station.	Atlas-sheet No.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of needle.	Observer.	Computer.	Remarks.
				° ′ ″	Feet.	° ′ ″			
1873	La Veta Creek, Colorado	62	Polaris α Lyræ α Arietis	37 31 42. 40	....	14 07 17	Lieut. Marshall	Lieut. Marshall	Two miles above junction with Cucharas River.
1874	Abiquiu, N. Mex	69 D	Sun Polaris ε Pegasi α Andromedæ α Aquilæ	36 12 29. 40	5930. 1	13 54 01	Lieut. Birnie	Lieut. Birnie	River bank below town.
1872	Adamsville, Utah	59	Polaris α Coronæ ε Pegasi α Aquilæ	38 15 00. 27	5600. 0	....	Lieut. Hoxie	Lieut. Hoxie	
1874	Alamosa Creek, Colorado	61 D	α Aquilæ α Pegasi Polaris	37 20 51. 70	11156. 4	....	Lieut. Wheeler	Lieut. Whipple	Near head South Fork.
1873	Alma City, Colorado	52 D	Polaris α Lyræ α Bootis	39 18 28. 76	10254. 0	14 35 00	Lieut. Marshall	Lieut. Marshall	Camp southeast of town one-quarter mile.
1869	Antelope Springs, Nev	49	Sun	....	....	....			
			α Aquilæ	39 25 42. 19	7201. 0	17 00 27	Lieut. Wheeler Lieut. Lockwood	Lieut. Wheeler Lieut. Lockwood	
1872	Antelope Springs, Utah	59	α Ophiuchi α Andromedæ Polaris	37 46 26. 50	5850. 0	16 20 00	Lieut. Marshall	Lieut. Marshall	On road from Cedar City, Utah, to Pioche, Nev.
1873	Animas City, Colorado	61 C	Polaris α Cygni α Lyræ	37 24 22. 70	6662. 3	....	Lieut. Marshall	Lieut. Marshall	
1873	Arkansas River, Colorado	61 B	Polaris α Cygni α Bootis	38 28 30. 00	7006. 5	14 41 00	Lieut. Marshall	Lieut. Marshall	Near Mouth of Badger Creek, Colorado.
1871	Camp Apache, Ariz	83	Sun α Coronæ α Cygni β Persei α Persei α Pegasi α Aquilæ α Andromedæ	33 47 18. 21	5000. 9	14 10 42	Lie t. Wheeler Lieut. Lockwood	Lieut. Lockwood	
1873	Camp Apache, Ariz	83	Polaris	33 47 18. 70	....	....	Li . Tillman	Lieut. Tillman	Camp separated by a short distance and near crossing of White Mountain Creek.

Geographical positions from sextant-observations, &c.—Continued.

Year.	Station.	Atlas-sheet No.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of needle. E.	Observer.	Computer.	Remarks.
				° ′ ″	*Feet.*	° ′ ″			
1872	Azay's Ranch, Utah	59	Polaris α Aquilæ	37 33 55.28	....	16 51 00	Lieut. Hoxie	Lieut. Hoxie	
1871	Ash Meadows, Nev	66	Sun	36 31 06.90	....	....	Lieut. Wheeler	Lieut. Lockwood	
1871	At-too-bah, or Cañon Spring, Ariz.	66	Polaris α Coronæ α Pegasi	35 44 43.28	....	14 06 00	Lieut. Lockwood	Lieut. Lockwood	
1873	Argentine Pass, Colorado	52 D	Polaris α Lyræ	39 38 40.90	11018.4	16 09 15	Lieut. Marshall	Lieut. Marshall	Camp near.
1872	Basin rim, Utah	59	Polaris α Aquilæ α Persei	37 41 05.60	7427.0	....	Lieut. Marshall	Lieut. Marshall	West of Last Bluff, at spring in break of Wahsatch plateau.
1871	Beaver Creek, Ariz	75	Polaris β Andromedæ α Lyræ	34 44 02.52	3671.4	....	Lieut. Lockwood	Lieut. Lockwood	Camp on.
1874	Beaver Creek, Colorado	61 D	Polaris α Arietis α Pegasi	37 36 09.60	8415.5	....	Lieut. Marshall	Lieut. Marshall	Mouth of tributary of South Fork Rio Grande.
1871	Beaver Dam, Nev	66	Sun Polaris	36 53 57.61	....	....	Lieut. Lockwood	Lieut. Lockwood	
1872	Beaver Lake district, Utah	59	Polaris α Coronæ Bor. ε Pegasi	38 31 25.93	....	....	Lieut. Hoxie	Lieut. Marshall	
1869	Benson's Creek, Nev	58	Polaris	38 40 41.33	6064.6	16 24 00	Lieut. Wheeler	Lieut. Wheeler	
1873	Big Hills, Ariz	83	Sun β Andromedæ α Andromedæ Polaris α Coronæ Bor.	33 23 07.70	5702.5	13 06 08	Lieut. Lockwood Lieut. Tillman	Lieut. Lockwood Lieut. Tillman	
1872	Black Rock Spring, Utah	59	Polaris α Bootis ε Pegasi	38 42 33.59	....	16 02 00	Lieut. Hoxie	Lieut. Marshall	
1873	Blue River, Colorado	52	Polaris α Lyræ α Bootis	39 42 54.97	8525.7	14 37 10	Lieut. Marshall	Lieut. Marshall	Eight miles from junction Ten-Mile Creek.

1871	Bouchés Fork, Ariz.	76	γ Andromedæ	34 33 08.54	5820.1	14 51 29	Lieut. Lockwood	Lieut. Lockwood	
			α Cygni						
			Polaris						
1872	Box Cañon Spring, Utah	59	Polaris	37 30 39.39	6509.0	....	Lieut. Marshall	Lieut. Marshall	On trip from Potato Valley to Paria settlement.
			α Persei						
			α Lyræ						
1873	Buffalo Slough, (divide at head of.)	61 B	Polaris	38 47 28.80	9723.9	14 24 42	Lieut. Marshall	Lieut. Marshall	
			α Cygni						
1873	Camp Bowie, Ariz	89	Sun	32 10 16.2	4871.6	....	Lieut. Tillman	Lieut. Tillman	
			Polaris						
			γ Pegasi						
			α Coronæ Bor						
			α Andromedæ						
			β Andromedæ						
1872	Old Camp Floyd, Utah	50	Sun	40 15 54.83	4866.5	16 59 30	Lieut. Hoxie	Lieut. Marshall	Near Fairfield in Cedar Valley.
			Polaris						
			α Bootis						
			α Aquilæ						
1871	Camp Pinal, Ariz	83	....	33 21 01.45	....	....	Lieut. Lockwood	Lieut. Lockwood	
1871	Camp Verde, Ariz	75	Polaris	34 34 20.19	3159.7	....	Lieut. Wheeler	Lieut. Lockwood	
			β Andromedæ				Lieut. Lockwood		
			α Lyræ						
1872	Camp L, Utah	59	Polaris	37 30 03.70	....	....	Lieut. Hoxie	Lieut. Hoxie	
			α Lyræ						
			α Tauri						
1872	Camp S, on Virgin River, Utah.	67	Polaris	37 08 06.60	....	15 29 00	Lieut. Hoxie	Lieut. Hoxie	
			α Herculis						
			α Pegasi						
			α Aquilæ						
1872	Camp 17, Utah	50	Polaris	39 17 59.50	....	....	Lieut. Hoxie	Lieut. Hoxie	
			α Lyræ						
1873	Cañada Alamosa, N. Mex	84	Polaris	33 32 15.00	6540.0	....	Lieut. Tillman	Lieut. Tillman	
			α Andromedæ						
			α Lyræ						
1869	Cave Valley, Nev	58	Sun	38 39 00.69	6463.8	16 16 13	Lieut. Wheeler	Lieut. Wheeler	
			Polaris				Lieut. Lockwood	Lieut. Lockwood	Camp near entrance to cave.
			α Aquilæ						
1871	Cedar Creek, Ariz	76	α Orionis	34 04 03.44	....	....	Lieut. Lockwood	Lieut. Lockwood	Altitude at mouth, 4037.2.
			α Pegasi						
			Polaris						
1872	Cedar Springs, Utah	50	α Aquilæ	39 08 04.70	5100.0	17 09 00	Lieut. Marshall	Lieut. Marshall	Camp 1½ miles north of east of town.
			α Coronæ						
			Polaris						
1874	Cement Creek, Colo	61 C	Sun	37 54 04.30	11483.6	14 58 00	Lieut. Marshall	Lieut. Marshall	Head of creek.
1874	Cañon de Chaco, N. Mex	68 D	Sun	36 06 31.90	5838.7	13 29 42	Lieut. Birnie	Lieut. Birnie	
			Polaris						
			Pegasi						
			α Andromedæ						
1874	North of Cañon de Chaco, N. Mex.	68 D	Polaris	36 03 18.80	6326.2	13 46 57	Lieut. Birnie	Lieut. Birnie	Mesa north of cañon.
			ε Pegasi						
			α Andromedæ						

Geographical positions, from sextant-observations, &c.—Continued.

Year.	Station.	Atlas-sheet No.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of needle. E.	Observer.	Computer.	Remarks.
				° ′ ″	Feet.	° ′ ″			
1873	Camp Chase, N. Mex	84	Polaris α Andromedæ α Lyræ	33 16 37.70	5374.2	....	Lieut. Tillman	Lieut. Tillman	Headwaters Cuchilla Negra.
1874	Chico Rito, N. Mex	70 B	Polaris ε Pegasi α Lyræ α Andromedæ	36 49 17.30	....	....	Lieut. Blunt	Lieut. Blunt	East of Clifton.
1873	Cienega San Simeon, N. Mex	89	Polaris α Coronæ β Andromedæ	32 04 08.50	3854.8	12 56 53	Lieut. Tillman	Lieut. Tillman	
1874	Cimarron, N. Mex	70 A	Polaris α Andromedæ α Pegasi	36 01 40.60	6418.9	....	Lieut. Birnie	Lieut. Birnie	Camp in cañon near.
1872	Circleville, Utah	59	α Coronæ Bor Polaris α Andromedæ	38 09 51.90	5624.0	21 30 00	Lieut. Marshall	Lieut. Marshall	
1869	Clear Creek, Nev	58	Polaris	38 50 07.73	6022.5	16 26 44	Lieut. Wheeler	Lieut. Wheeler	Spring Valley, eastern side.
1869	Clover Valley, Nev	58	α Pegasi Polaris α Aquilæ	37 30 27.00	4902.0	14 25 19	Lieut. Wheeler Lieut. Lockwood	Lieut. Wheeler Lieut. Lockwood	
1869	Cold Spring, Nev	49	α Aquilæ Polaris	40 04 01.86	6173.1	17 12 27	Lieut. Wheeler	Lieut. Wheeler	
1872	Cottonwood Cañon, Utah, (head of.)	59	α Lyræ Polaris α Arietis	37 25 50.80	5973.0	....	Lieut. Marshall	Lieut. Marshall	
1871	Cottonwood Springs, Nev	66	Sun Polaris α Pegasi α Coronæ Bor	36 03 10.53	3449.5	....	Lieut. Wheeler Lieut. Lockwood Lieut. Lyle	Lieut. Lockwood	
1873	Cottonwood Creek, Utah, N.	50	Polaris α Lyræ α Bootis γ Ursæ Majoris	39 13 38.50	5790.8	16 50 00	Lieut. Hoxie	Lieut. Tillman	Camp on creek, Joe's Valley.
1873	Cottonwood Creek, Utah, S	50	Jupiter Polaris α Bootis α Lyræ	39 04 46.50	6055.1	16 16 00	Lieut. Hoxie	Lieut. Marshall	Camp on creek.
1873	Cow Spring, N. Mex	84	Polaris α Andromedæ α Lyræ	32 22 02.00	4954.1	11 54 45	Lieut. Tillman	Lieut. Tillman	

1874	Coyote Creek, N. Mex	70 C	Polaris α Coronæ Bor α Pegasi α Aquilæ	36 08 27.40	7054.7	14 15 00	Lieut. Blunt	Lieut. Blunt	7 miles west and 5 miles north of Guadalupita.
1873	Fort Craig, N. Mex	84	Sun Polaris α Andromedæ α Lyræ	33 38 27.00	4619.0	12 59 09	Lieut. Tillman	Lieut. Tillman	
1873	Cucharas River, Colorado	62 C	Polaris α Persei α Cygni	37 30 15.60	......	14 00 38	Lieut. Marshall	Lieut. Marshall	
1873	Cummings, Fort, N. Mex	84	Polaris α Andromedæ α Lyræ	32 26 54.00	4777.7	12 29 47	Lieut. Tillman	Lieut. Tillman	
1873	Currant Creek, Colorado	61 B	Polaris α Cygni	38 39 29.30	8038.8	14 24 07	Lieut. Marshall	Lieut. Marshall	Two miles below Mound Soda Springs.
1873	Deer Spring, N. Mex	76	Polaris α Aquilæ α Coronæ Bor α Pegasi	34 50 32.65	5981.9	13 53 32	Lieut. Hoxie	Lieut. Tillman	
1872	Deseret City, Utah	50	Polaris α Cygni	39 14 04.70	4642.0	16 14 00	Lieut. Hoxie	Lieut. Hoxie	
1871	Desert Springs, Cal	73 A	α Aquilæ α Bootis Polaris	35 18 26.10	1989.0	15 31 00	Lieut. Lockwood	Lieut. Lockwood	
1872	Desert Spring, Utah	58	α Ophiuchi α Andromedæ Polaris	37 49 24.20	5887.0	16 20 00	Lieut. Marshall	Lieut. Marshall	
1871	Desert Station, Ariz	82	α Persei α Lyræ Polaris	32 30 08.80	2135.2	....	Lieut. Lockwood	Lieut. Lockwood	
1871	Diamond Creek, Ariz	67	Sun Polaris	35 45 19.11	1,350.4	....	Lieut. Wheeler Lieut. Lockwood	Lieut. Lockwood	Mouth of.
1874	Diana Creek, Colorado	61 C	Sun Polaris	37 42 12.00	9473.0	14 32 00	Lieut. Marshall	Lieut. Marshall	Under Engineer Peak.
1873	Dirty Devil Cañon, Utah	59	Polaris α Serpentis α Lyræ	38 17 24.70	5517.8	16 18 00	Lieut. Hoxie	Lieut. Tillman	Camp in.
1873	Dirty Devil River, Utah	59	Polaris α Serpentis α Lyræ α Bootis	38 16 21.70	5056.9	16 20 00	Lieut. Hoxie	Lieut. Tillman	Camp in cañon of.
1873	Dirty Devil River, Utah	59	Polaris α Bootis α Aquilæ	38 16 43.00	5480.5	....	Lieut. Hoxie	Dr. F. Kampf	Near Camp 23.
1871	Disaster Rapids, Ariz	66	Sun	35 55 52.10	......	....	Lieut. Wheeler	Lieut. Lockwood	At foot of, on Colorado River.
1874	Dolores River, Colorado	61 C	ε Pegasi Sun	37 46 53.60	9633.2	14 09 34	Lieut. Whipple	Lieut. Whipple	Near headwaters.

Geographical positions, from sextant-observations, &c.—Continued.

Year.	Station.	Atlas-sheet No.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of needle. E	Observer.	Computer.	Remarks.
				° ′ ″	*Feet.*	° ′ ″			
1874	Dolores River, Colorado	61 C	Polaris	37 30 37.40	7074.7	14 00 00	Lieut. Whipple ...	Lieut. Whipple ...	
			α Andromedæ...						
			α Lyræ						
			ε Pegasi						
1874	Dolores River, Colorado	61 C	Polaris	37 25 27.40	6534.1	....	Lieut. Whipple ...	Lieut. Whipple ...	
			α Andromedæ...						
			α Lyræ						
			ε Pegasi						
1873	Dome Spring, Utah	59	Polaris.........	37 30 41.80	3774.7	15 34 00	Lieut. Hoxie......	Dr. Kampf	
			α Serpentis						
			α Bootis.........						
			α Lyræ						
1873	Doubtful Apache, N. Mex ..	84	Polaris	32 53 54.50	5546.7	....	Lieut. Tillman ...	Lieut. Tillman....	
			α Andromedæ...						
			α Lyræ						
1873	Dry Camp, on trail from Paria, Utah, to Oraybe, Ariz.	68	Polaris.........	35 58 07.80	4955.2	14 42 47	Lieut. Hoxie	Lieut. Marshall...	Camp 56.
			ε Pegasi						
			α Coronæ						
			α Aquilæ						
1873	Dry Camp, N. Mex	83	Polaris	32 20 57.60	4323.2	....	Lieut. Hoxie......	Lieut. Marshall...	Near Ralston.
			ε Pegasi						
			α Lyræ						
			α Andromedæ ..						
1873	East River, 1 mile above junction with Gunnison.	61 A	Polaris	38 40 52.80	7991.6	....	Lieut. Marshall ...	Lieut. Marshall ...	
			α Coronæ Bor...						
1873	East River trail.............	61 A	Polaris	38 49 07.60	9442.8	....	Lieut. Marshall ..	Lieut. Marshall ..	On Spring Creek.
			α Coronæ Bor ..						
1869	Eldorado Cañon, Nev	66	Polaris	35 43 55.36	828.0	....	Lieut. Wheeler ...	Lieut. Wheeler ...	Camp near bank of Colorado River.
			α Aquilæ				Lieut. Lockwood..	Lieut. Lockwood..	
1874	Embuda, N. Mex............	69 D	Polaris	36 11 13.20	5891.0	13 15 07	Lieut. Birnie	Lieut. Birnie	
1873	Escudilla Peak, near........	83	α Coronæ Bor..	33 59 07.40	7368.4	12 32 58	Lieut. Hoxie......	Lieut. Tillman...	Base of, near Arizona and New Mexico boundary.
			Polaris						
			α Aquilæ						
			α Pegasi........						
1872	Eureka City, Utah	50	α Bootis	39 58 08.90	6400.0	17 09 00	Lieut. Marshall ...	Lieut. Marshall ...	One and one-half mile east of, between Eureka and Homansville.
			α Aquilæ						
			Polaris........						

1872	Fairfield, Utah	50	Sun Polaris α Bootis	40 15 54.53	4866.5	16 59 30	Lieut. Hoxie	Lieut. Marshall	Camp near, and old Camp Floyd.
1873	Fair Play, Colorado	52 D	α Aquilæ Polaris α Lyræ	39 11 35.30	10054.0	14 35 00	Lieut. Marshall	Lieut. Marshall	Camp west of, under Bald Peak.
1872	Faust's Station, Utah	50	α Bootis Polaris	40 11 42.33	5296.0	16 51 42	Lieut. Hoxie	Lieut. Marshall	
1872	Fiddlebridge Mountain, Utah	59	ε Pegasi Polaris	38 59 19.86	5339.0	....	Lieut. Hoxie	Lieut. Marshall	
1873	Fish Lake, Utah	59	α Tauri Polaris α Aquilae	38 32 09.70	8763.2	....	Lieut. Hoxie	Dr. Kampf	
1872	Fish Spring, Utah	50	α Coronæ Bor Sun Polaris α Aquilæ	39 52 11.98	4269.0	17 04 48	Lieut. Hoxie	Lieut. Marshall	
1871	Florence, Ariz	82	α Persei α Cygni	33 02 32.53	....	....	Lieut. Lockwood	....	
1873	Florida River, Colorado	69 A	Polaris Polaris	37 16 16.00	6918.0	....	Lieut. Marshall	Lieut. Marshall	On Macomb's trail.
1873	Gallo Spring, N. Mex	76	α Lyræ Polaris α Coronæ Bor	34 01 35.60	7924.8	....	Lieut. Hoxie	Lieut. Tillman	
1873	Garland, Fort	62 C	α Pegasi α Aquilæ Sun Polaris α Persei	37 25 28.11	7863.7	14 07 08	Lieut. Marshall	Lieut. Marshall	See also Lieutenant Wheeler's observations at Smith's Island, a little north of west.
1873	Geyser Spring, N. Mex	83	α Lyræ Polaris α Ophiuchi	33 07 58.10	5399.7	13 29 54	Lieut. Hoxie	Lieut. Tillman	
1873	Gila River, N. Mex	83	α Aquilæ α Pegasi Polaris α Andromedæ	32 53 22.00	3477.3	....	Lieut. Hoxie	Lieut. Marshall	
1873	......do	83	ε Pegasi	32 41 00.00	3731.5	....	Lieut. Hoxie	Lieut. Marshall	
1874	Godwin Creek, Colorado	61	Polaris α Aquilæ α Pegasi	37 59 38.60	9430.1	15 00 00	Lieut. Marshall	Lieut. Marshall	Five miles below head.
1872	Gould's Ranch, Utah	67	α Coronæ Bor Polaris α Cygni	37 09 14.70	4052.5	....	Lieut. Marshall	Lieut. Marshall	Old Fort Defiance.
1873	Green Springs, Ariz	67	α Persei α Coronæ Polaris ε Pegasi	36 11 13.00	4931.2	15 28 24	Lieut. Hoxie	Lieut. Tillman	
1872	Grass Valley, Utah	59	α Aquilæ α Ophiuchi Sun	38 33 28.36	6857.0	17 45 00	Lieut. Marshall	Lieut. Marshall	Camp near trail to Fish Lake.

Geographical positions, from sextant-observations, &c.—Continued.

Year.	Station.	Atlas-sheet No.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of needle. E	Observer.	Computer.	Remarks.
				° ′ ″	*Feet.*	° ′ ″			
1872	Grass Valley, Utah	59	Polaris	38 19 58. 56	6507. 0	17 45 13	Lieut. Marshall	Lieut. Marshall	
			α Andromedæ						
			α Lyræ						
1872	Gunnison, Utah, rendezvous camp at.	50	Sun	39 08 58. 70	5144. 0	....	Lieut. Wheeler	Lieut. Marshall	For position of astronomical monument, see list of main astronomical positions.
			α Coronæ Bor.				Lieut. Marshall		
			β Pegasi						
			α Andromedæ						
			α Aquilæ						
			Polaris						
1873	Gunnison's Trail, Utah	59	Polaris	38 47 37. 90	7635. 4	16 00 00	Lieut. Hoxie	Lieut. Tillman	
			α Serpentis						
			α Lyræ						
			α Bootis						
1872	Gunnison Valley, Utah	59	α Coronæ	38 51 06. 18	6732. 3	....	Lieut. Marshall	Lieut. Marshall	
			Polaris						
			β Pegasi						
1869	Hawawah Spring, Utah	59	Sun	38 29 47. 46	5550. 0	16 39 56	Lieut. Wheeler	Lieut. Wheeler	
			Polaris				Lieut. Lockwood	Lieut. Lockwood	
1874	Hayden Creek, Colorado	61 B.	Polaris	38 20 24. 60	7127. 3	14 05 30	Lieut. Marshall	Lieut. Marshall	
			Sun						
			α Ophiuchi						
			α Bootis						
1872	Hay Spring, Utah	59	Polaris	38 19 18. 28	5092. 0	16 15 36	Lieut. Hoxie	Lieut. Marshall	
			α Coronæ Bor.						
			α Aquilæ						
			ε Pegasi						
1873	High Creek, Colorado	62 A	Polaris	38 41 10. 00	....	15 00 43	Lieut. Marshall	Lieut. Marshall	
			Sun						
			α Lyræ						
			α Cygni						
1869	Homer, Cedar Valley, Nev.	58	α Pegasi	38 03 23. 40	5821. 0	17 40 27	Lieut. Wheeler	Lieut. Wheeler	
			Polaris						
			α Aquilæ						
1869	Ice Creek, Nev	49	Polaris	39 02 28. 23	7084. 2	16 35 06	Lieut. Wheeler	Lieut. Wheeler	
			α Aquilæ				Lieut. Lockwood	Lieut. Lockwood	
1869	Indian Spring, Nev	66	Sun	36 34 01. 04	....	15 41 29	Lieut. Wheeler	Lieut. Wheeler	
			Polaris				Lieut. Lockwood	Lieut. Lockwood	
1872	Indian Spring, Utah	50	Polaris	39 59 28. 72	5771. 0	....	Lieut. Hoxie	Lieut. Marshall	
			ε Pegasi						

1872	Iron City, Utah	59	α Andromedæ α Ophiuchi Polaris	37 33 11.18	6099.0	18 30 00	Lieut. Marshall	Lieut. Marshall	Camp two miles south of, on Pinto and Cedar City road.
1871	Ivanpah, Nev	74	Polaris α Coronæ Bor α Pegasi	35 33 14.54	4483.0	....	Lieut. Lockwood	Lieut. Lockwood	
1874	La Jara Valley, N. Mex	69	Sun Polaris ε Pegasi α Andromedæ	36 05 02.70	6988.4	14 05 54	Lieut. Birnie	Lieut. Birnie	Camp in.
1873	Jefferson, South Park, Colo	53 C	Polaris α Lyræ α Bootis	39 24 36.40	9862.5	....	Lieut. Marshall	Lieut. Marshall	
1873	Joe's Valley, East side, Utah	50	Polaris α Bootis γ Ursæ Majoris α Lyræ	39 24 33.00	8420.3	17 00 00	Lieut. Hoxie	Lieut. Tillman	
1874	Laguna del Ojo Hediondo, N. Mex.	69 A	Polaris α Aquilæ α Coronæ Bor Sun	36 37 42.50	7181.2	14 15 49	Lieut. Birnie	Lieut. Birnie	On east side.
1869	Lake Creek, Source of, Nev	58	Sun	38 40 38.45	5464.0	15 57 42	Lieut. Wheeler Lieut. Lockwood	Lieut. Wheeler Lieut. Lockwood	
1873	Lake Creek, Colo., Cabins at forks of.	52	Polaris α Coronæ Bor	39 02 33.70	10795.0	....	Lieut. Marshall	Lieut. Marshall	
1873	La Loma, Colo	61 D	Sun Polaris	37 40 59.30	7742.5	14 53 00	Lieut. Marshall	Lieut. Marshall	On Rio Grande, below town.
1874	Largo Cañon, N. Mex	69 A	Polaris α Coronæ Bor α Aquilæ Sun α Andromedæ	36 39 33.40	5650.8	14 10 23	Lieut. Birnie	Lieut. Birnie	Junction cañons Largo Blanco and Cerezal, (Camp 23.)
1869	Las Vegas Ranch, Nev	66	Sun Polaris	36 11 15.15	2074.0	15 08 11	Lieut. Wheeler Lieut. Lockwood	Lieut. Wheeler Lieut. Lockwood	
1871	Leach's Point, Cal	73	Sun α Aquilæ α Bootis Polaris	35 33 32.46	3408.6	15 06 00	Lieut. Lockwood	Lieut. Lockwood	
1873	Leidendorf's Wells, N. Mex	89	Polaris α Andromedæ α Coronæ Bor	32 14 04.00	4601.4	12 17 49	Lieut. Tillman	Lieut. Tillman	
1873	Limestone Water Pocket, Ariz.	67	Polaris α Aquilæ α Coronæ Bor ε Pegasi	36 32 18.40	5405.4	15 15 45	Lieut. Hoxie	Lieut. Marshall	
1872	Lincoln District, Utah	59	Polaris ε Pegasi α Coronæ α Aquilæ	38 15 22.00	....	....	Lieut. Hoxie	Lieut. Hoxie	

Geographical positions, from sextant-observations, &c.—Continued.

Year.	Station.	Atlas-sheet No.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of needle. E.	Observer.	Computer.	Remarks.
				° ′ ″	Feet.	° ′ ″			
1873	Line Colorado and New Mexico.	70 A	Polaris α Persei α Lyræ	36 59 55.80	8757.4	14 01 16	Lieut. Marshall	Lieut. Marshall	On creek south of Francisco Pass.
1871	Little Colorado Crossing, (near mouth of Puerco.)	76	....	34 53 16.80	5083.3	....	Lieut. Lockwood	Lieut. Lockwood	
1874	Los Pinos River, Colo	61 C	α Andromedæ Polaris α Lyræ ε Pegasi	37 29 10.85	9774.6	14 35 37	Lieut. Whipple	Lieut. Whipple	Tributary San Juan.
1874	Los Pinos Indian agency, Colo.	61 B	Sun Polaris β Pegasi	38 11 36.50	9064.8	14 50 00	Lieut. Marshall	Lieut. Marshall	Six-tenths mile southeast.
1873	Mammoth Mill, Utah	58	Polaris α Cygni	38 04 43.90	6947.0	15 52 00	Lieut. Hoxie	Lieut. Hoxie	
1872	Meadow Creek, Utah	59	α Coronæ Bor ε Pegasi Polaris	38 51 20.12	5992.5	16 11 00	Lieut. Hoxie	Lieut. Marshall	
1872	Mill Spring Station, Utah	59	Polaris α Cygni	38 17 26.80	6504.0	17 20 00	Lieut. Hoxie	Lieut. Hoxie	
1872	Minersville, Utah	59	α Herculis α Andromedæ Polaris	38 12 54.59	....	16 30 00	Lieut. Marshall	Lieut. Marshall	
1873	Moen-copie Cañon, Ariz	67	Polaris ε Pegasi α Aquilæ α Coronæ Bor	36 08 03.00	4984.1	14 23 43	Lieut. Hoxie	Lieut. Marshall	Mormon wagon-road.
1873	Monica Spring, N. Mex	84	Polaris α Lyræ β Andromedæ	33 55 09.90	7735.3	....	Lieut. Tillman	Lieut. Tillman	
1869	Monument Cañon, Nev	58	Polaris α Aquilæ	38 38 06.00	6114.0	16 31 54	Lieut. Wheeler Lieut. Lockwood	Lieut. Wheeler Lieut. Lockwood	Indian Springs.
1874	Mora Cañon, N. Mex	70	Polaris ε Pegasi α Lyræ α Andromedæ	35 48 49.60	6527.6	....	Lieut. Blunt	Lieut. Blunt	8.5 miles south, 25 miles east of Fort Union.
1874	Mora River, N. Mex	70 C	Sun	35 59 03.50	7042.7	14 40 00	Lieut. Blunt	Lieut. Blunt	0.5 mile south, 1.75 miles east of Lower Mora settlement.
1869	Mormon Cañon, Meadow Creek, Nev.	66	Polaris Sun	37 16 23.06	3092.9	16 34 30	Lieut. Wheeler Lieut. Lockwood	Lieut. Wheeler Lieut. Lockwood	

1873	Montezuma, Colo	52 D	Polaris α Lyræ Sun	39 30 23.70	9651.8	15 49 15	Lieut. Marshall	Lieut. Marshall	On Snake River, north of town.
1871	Mosquito Spring, Cal	73	α Aquilæ α Bootis	35 23 03.99	2009.8	15 30 00	Lieut. Lockwood	Lieut. Lockwood	
1872	Mountain Meadows, Utah	59	Polaris Sun Polaris	37 32 18.10	5741.8	....	Lieut. Hoxie	Lieut. Hoxie	
1873	Mount Pleasant, Utah	50	α Aquilæ α Andromedæ Sun α Lyræ Polaris	39 32 17.40	6089.6	17 10 00	Lieut. Hoxie	Lieut. Marshall	
1873	Mule Spring, N. Mex	84	γ Ursæ Majoris α Bootis Polaris α Andromedæ α Lyræ	32 37 36.50	5281.8	13 08 49	Lieut. Tillman	Lieut. Tillman	
1869	Mud Spring, Nev	66	....	37 11 06.88	4900.0	16 02 45	Lieut. Wheeler Lieut. Lockwood	Lieut. Wheeler Lieut. Lockwood	
1873	Muddy Creek, Utah	59	Polaris α Bootis α Serpentis α Lyræ	38 58 58.90	6360.0	16 00 00	Lieut. Hoxie	Lieut. Tillman	
1873	Muddy Creek, Colo	62	Sun	37 56 22.10	....	14 07 27	Lieut. Marshall	Lieut. Marshall	Near head.
1869	Murray's Creek, Nev	49	Sun Polaris	39 15 15.80	6411.0	16 35 18	Lieut. Wheeler Lieut. Lockwood	Lieut. Wheeler Lieut. Lockwood	
1873	Navajo, Rio	69 B	Polaris α Persei α Cygni	37 01 51.40	....	....	Lieut. Marshall	Lieut. Marshall	Near Pagosa Spring and Tierra Amarilla trail.
1873	Navajo Spring, Ariz	67	Polaris ε Pegasi α Coronæ Bor. α Aquilae	36 46 19.10	4410.2	....	Lieut. Hoxie	Lieut. Tillman	
1871	New Creek, (Ives's,) Ariz	75	α Pegasi α Coronæ Bor. Polaris	35 36 51.00	....	....	Lieut. Lockwood	Lieut. Lockwood	Pahroach Spring.
1871	Nelson's Tanks, Ariz	75	Polaris β Andromedæ α Lyræ	34 46 20.42	6216.5	....	Lieut. Lockwood	Lieut. Lockwood	Mogollon mesa.
1873	North Fork, Utah	50	Polaris α Virginis α Lyrae	39 51 11.40	5046.2	....	Lieut. Hoxie	Lieut. Tillman	Price River.
1873	Nutria Spring, N. Mex	76	Polaris α Ophiuchi α Pegasi α Aquilæ	35 18 13.65	6934.0	14 16 09	Lieut. Hoxie	Lieut. Tillman	
1872	Oak Creek Cañon, Utah	50	α Bootis α Aquilæ Polaris	39 21 10.70	5158.0	....	Lieut. Marshall	Lieut. Marshall	Two miles east of Oak Creek City, Utah.

Geographical positions, from sextant-observations, &c.—Continued.

Year.	Station.	Atlas-sheet No.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of needle. E.	Observer.	Computer.	Remarks.
				° ′ ″	Feet.	° ′ ″			
1873	Oak Spring, N. Mex	76	Polaris α Coronæ Bor α Aquilæ α Pegasi	34 03 18.20	7946.4	12 34 42	Lieut. Hoxie	Lieut. Tillman	
1874	Ocate River, N. Mex	70 C	α Coronæ Bor α Pegasi Polaris α Aquilæ	36 10 20.50	7076.6	14 15 06	Lieut. Blunt	Lieut. Blunt	Near Las Gallinas.
1874	Ojo Caliente Creek, N. Mex., (Camp on, No. 19.)	69 D	Sun Polaris ϵ Pegasi α Andromedæ	36 17 07.40	6043.7	13 15 00	Lieut. Birnie	Lieut. Birnie	One mile south of springs.
1873	Oraybe, Ariz	68	Polaris ε Pegasi α Aquilæ α Coronæ Bor	35 52 57.60	4756.8	....	Lieut. Hoxie	Lieut. Marshall	Tanks near.
1872	Otter Creek, Utah, head of	59	α Coronæ Bor β Pegasi Polaris	38 42 35.20	7447.7	....	Lieut. Marshall	Lieut. Marshall	
1874	Pagosa Springs, Colo	69 A	Polaris Markab Sun Altair	37 15 41.40 15 44.10	7108.6	14 39 30	Lieut. Wheeler Lieut. Marshall Lieut. Whipple	 Lieut. Marshall Lieut. Whipple	
1871	Pahghun Pahghun Springs, Ariz.	66	α Arietis Sun α Coronæ Bor γ Pegasi β Capricorni Polaris	36 24 51.83	2281.9	....	Lieut. Lyle Mr. Marvine	Lieut. Lockwood	
1871	Pah-roach Spring, Ariz	....	α Coronæ Bor α Pegasi Polaris	35 36 51.00	....	14 15 00	Lieut. Lockwood	Lieut. Lockwood	New Creek of Ives.
1872	Panquitch, Utah	59	Sun Polaris	37 49 34.00	6273.3	....	Lieut. Marshall	Lieut. Marshall	Camp 3 miles north of, on Sevier.
1872	Paragoonah, Utah	59	α Coronæ Polaris α Andromedæ	37 54 44.97	6222.0	19 30 00	Lieut. Marshall	Lieut. Marshall	One and one-half mile north of.

1872	Paria, Utah	67	Sun Polaris α Persei α Cygni	37 10 42.97	4562.1	14 13 00	Lieut. Marshall	Lieut. Marshall	
1872	Paria River, Utah, mouth of.	67	Sun Polaris α Persei α Cygni	36 51 13.20	3017.6	....	Lieut. Marshall	Lieut. Marshall	River-bank at mouth.
1872	Paria River Cañon, at great bend.	67	Polaris α Lyræ α Persei	36 58 34.24	3873.5	....	Lieut. Marshall	Lieut. Marshall	
1872	Paria River, camp near head, Utah.	59	Polaris α Aquilæ	37 32 11.57	....	....	Lieut. Hoxie	Lieut. Hoxie	
1872	Paria River Cañon	67	Polaris α Aquilæ	37 14 11.94	....	14 13 00	Lieut. Hoxie	Lieut. Hoxie	Where Paria and Kanab road leaves river.
1873	Passinyo Camp, N. Mex	84	Polaris α Andromedæ α Lyræ	32 43 46.00	4444.8	....	Lieut. Tillman	Lieut. Tillman	
1873	Peach Orchard Spring, Ariz	68	Polaris ε Pegasi α Aquilæ α Coronæ Bor.	35 46 42.40	6297.5	....	Lieut. Hoxie	Lieut. Hoxie	
1869	Pearl Creek, Nev	49	α Aquilæ Polaris	40 17 10.74	5965.1	16 18 51	Lieut. Wheeler Lieut. Lockwood	Lieut. Wheeler Lieut. Lockwood	
1874	Pecos Cañon, N. Mex	70	Sun	35 46 25.00	7984.2	....	Lieut. Blunt	Lieut. Blunt	Confluence of main branches.
1873	San Pedro River, Ariz	83	Polaris α Aquilæ α Ophiuchi α Pegasi	32 42 39.70	5874.5	12 49 20	Lieut. Hoxie	Lieut. Tillman	
1871	Picacho Station, Ariz	82	α Persei α Lyræ Polaris	32 44 20.67	1750.2	....	Lieut. Lockwood	Lieut. Lockwood	
1871	Picket Post, Ariz	83	α Persei α Cygni Polaris	33 17 01.27	2669.6	....	Lieut. Lockwood	Lieut. Lockwood	
1872	Piermont, Nev	49	Polaris Sun α Bootis α Aquilæ	39 28 42.15	5581.2	16 47 00	Lieut. Hoxie	Lieut. Marshall	Camp near O'Neil's Ranch.
1871	Pinal Creek	83	α Orionis α Pegasi Polaris	33 32 26.48	3112.2	....	Lieut. Lockwood	Lieut. Lockwood	Wheatfields.
1871	Pinal Mountains, Ariz	83	α Persei Polaris α Cygni	33 23 10.24	3925.5	....	Lieut. Lockwood	Lieut. Lockwood	
1872	Pine Valley, southwest of, Utah.	59	α Andromedæ α Herculis Polaris	37 23 33.80	....	16 00 00	Lieut. Marshall	Lieut. Marshall	Near Earle's ranch.
1873	Palomas Creek, N. Mex	84	Polaris α Andromedæ α Lyræ	33 09 18.00	5415.5	....	Lieut. Tillman	Lieut. Tillman	

Geographical positions, from sextant-observations, &c.—Continued.

Year.	Station.	Atlas-sheet No.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of needle. E	Observer.	Computer.	Remarks.
				° ′ ″	Feet.	° ′ ″			
1871	Portage Rapids, Ariz	66	Polaris........ α Aquilæ .... α Pegasi	35 48 35. 90	....	....	Lieut. Wheeler ...	Lieut. Wheeler ...	Above.
1872	Potato Valley, Utah, (head of.)	59	α Lyræ .... Polaris........ α Persei........	37 39 29. 02	7331. 9	....	Lieut. Marshall ...	Lieut. Marshall ..	
1872	Potato Valley, Springs in Mountains, south of head, Utah.	59	α Cygni...... .. Polaris....... α Persei	37 37 37. 90	8609. 6	....	Lieut. Marshall ...	Lieut. Marshall ...	
1873	Prieto Crossing, Ariz	83	Polaris .... α Andromedæ... α Coronæ	33 33 47. 30	5332. 8	12 36 19	Lieut. Tillman	Lieut. Tillman....	
1873	Pueblo Colorado, Ariz	68	Sun........... Polaris .... ε Pegasi .... α Coronæ Bor... α Aquilæ	35 42 10. 40	6400. 9	14 31 16. 3	Lieut. Hoxie......	Lieut. Hoxie......	
1873	Pueblo Viejo, Ariz..........	83	Sun........... β Andromedæ .. Polaris .... α Aquilæ .... α Pegasi .... α Coronæ Bor...	32 49 00. 10	2711. 6	14 10 47	Lieut. Tillman	Lieut. Tillman	Safford post-office.
1871	Puerco River, mouth, Ariz..	76	Altair .... γ Andromedæ .. Polaris	34 53 16. 80	5083. 3	....	Lieut. Lockwood..	Lieut. Lockwood..	
1873	Purgatoire River, Colo., (head north fork.)	70 A	Polaris .... α Lyræ .... Arietis	37 18 24. 60	8453. 2	14 22 48	Lieut. Marshall...	Lieut. Marshall...	West of Spanish peaks, on road from Cucharas River, Colo., to Elizabethtown, New Mex.
1869	Quinn Cañon, Nev	58	Sun........... Polaris	37 58 18. 29	6326. 0	16 20 15	Lieut. Wheeler ... Lieut, Lockwood..	Lieut. Wheeler ... Lieut. Lockwood..	
1873	Rabbit Valley, Utah, (foot of.)	59	Polaris .... α Serpentis ..... α Bootis .... α Lyræ	38 19 00. 10	6820. 8	16 20 00	Lieut. Hoxie......	Lieut. Marshall ...	
1873	Ralston, New Mex.........	89	Sun .... Coronæ .... Polaris .... α Pegasi ... . Andromedæ .. α Lyræ	32 18 10. 50	4487. 7	....	Lieut. Tillman .... Lieut. Hoxie......	Lieut. Tillman .... Lieut. Marshall ...	

1871	Rattlesnake Cañon, Ariz	75	β Andromedæ .. α Ophiuchi ..... Polaris	34 55 49.93	....	14 42 00	Lieut. Lockwood..	Lieut. Lockwood..	
1869	Rattlesnake Spring, Nev....	58	Sun...........	38 57 21.17	6038.2	16 17 54	Lieut. Wheeler ... Lieut. Lockwood..	Lieut. Wheeler ... Lieut. Lockwood..	Spring Valley.
1871	Relief Springs, Ariz.........	75	Polaris .... α Ophiuchi ..... α Pegasi........	35 08 34.28	5526.6	14 22 00	Lieut. Lockwood..	Lieut. Lockwood..	Lockwood Springs.
1874	Reynolds, Old Fort, Colo	62 A	Sun........... Polaris .... α Pegasi........	38 12 03.80	4300.0	....	Lieut. Blunt	Lieut. Blunt	
1874	Rio Grande, Colo............	61 C	Polaris ...... α Coronæ Bor... α Pegasi .... α Aquilæ	37 45 10.10	9816.0	14 50 00	Lieut. Marshall ...	Lieut. Marshall ...	Camp two miles below mouth of Pole Creek.
1874	Rio Grande, South Fork, at mouth of Beaver Creek.	61 D	α Pegasi........ Polaris .... α Arietis	37 36 09.60	8415.5	....	Lieut. Marshall ...	Lieut. Marshall ...	
1874	Rio Grande, Colo............	61 D	α Andromedæ .. Polaris .... α Lyræ .... ε Pegasi........	37 44 23.50	9787.4	....	Lieut. Whipple ...	Lieut. Whipple ...	Jennison's ranch.
1873	Rio Mimbres, N. Mex.......	84	Polaris .... α Andromedæ .. α Lyræ	32 30 46.00	4935.7	12 58 00	Lieut. Tillman	Lieut. Tillman ...	
1874	Rio Piedra, Colo............	61 C	Polaris .... α Andromedæ .. α Aquilæ .... α Pegasi........	37 28 15.20	7947.2	....	Lieut. Marshall ...	Lieut. Marshall ...	Camp on West Fork on trail from Rio Grande Cañon.
1874	Rio San Juan, Colo., under Station 22.	61 C	Sun...........	37 25 28.40	7776.7	....	Lieut. Marshall ...	Lieut. Marshall ...	At point where Pagosa and Del Norte trail leaves river.
1869	Rio Virgen, mouth of, Nev..	66	α Pegasi .... Polaris .... α Aquilæ.......	36 08 45.54	1200.0	15 47 11	Lieut. Wheeler ... Lieut. Lockwood..	Lieut. Wheeler ... Lieut. Lockwood..	
1869	Rose Valley, Nev...........	58	Sun .... Polaris .... α Pegasi	37 54 51.20	5401.0	17 50 09	Lieut. Wheeler ... Lieut. Lockwood..	Lieut. Wheeler ... Lieut. Lockwood..	
1869	Sacramento District, Nev ...	49	α Aquilæ....... Polaris	39 09 46 08	6574.0	16 27 22	Lieut. Wheeler ...	Lieut. Wheeler ..	
1874	Sage Plains, Colo...........	60	α Andromedæ .. α Lyræ .... α Pegasi........ Polaris	37 25 27.40	5824.8	14 34 38	Lieut. Whipple ...	Lieut. Whipple ...	
1873	Saguache, Colo., (Craig's Ranch.)	61 D	Sun...........	38 02 10.60	7463.8	14 34 43	Lieut. Marshall ...	Lieut. Marshall ...	
1872	Salina, Utah	59	Sun........... α Coronæ Bor... Polaris........ α Pegasi........	38 57 10.56	....	....	Lieut. Marshall ...	Lieut. Marshall ...	

Geographical positions, from sextant-observations, &c.—Continued.

Year.	Station.	Atlas-sheet No.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of needle. E.	Observer.	Computer.	Remarks.
				° ′ ″	*Feet.*	° ′ ″			
1873	San Antonio Creek, Colo.. ..	69 B	Polaris........ α Persei........ α Cygni........	37 01 02.10	7620	....	Lieut. Marshall ...	Lieut. Marshall ...	Near Los Pinos Plaza south of Conejos.
1873	San Francisco River, N. Mex	83	Polaris .... α Aquilæ ...... α Ophiuchi ..... α Pegasi........	33 11 44.80	3798.3	13 31 23	Lieut. Hoxie......	Lieut. Tillman	
1873	......do	83	Polaris........ α Aquilæ....... α Ophiuchi ..... α Pegasi........	33 02 27.80	3484.7	12 22 22	Lieut. Hoxie	Lieut. Tillman....	
1872	San Francisco Spring, Utah .	59	Polaris........ α Cygni	38 26 47.05	6527.1	16 58 00	Lieut. Hoxie	Lieut. Hoxie......	
1873	San Francisco River, N. Mex.	83	Polaris........ α Aquilæ.......	33 26 31.50	5177.9	13 49 20	Lieut. Hoxie	Lieut. Tillman	
1873	......do	83	α Pegasi .... α Ophiuchi	33 15 15.90	4706.6	12 51 43	Lieut. Hoxie	Lieut. Tillman	
1874	San Geronimo, N. Mex......	78 A	Polaris .... ε Pegasi........ α Andromedæ..	35 32 20.30	6724.5	....	Lieut. Blunt......	Lieut. Blunt	On Tecalete Creek.
1874	San Juan River, N. Mex . ..	69 A	Polaris .... α Coronæ Bor... α Aquilæ .... Sun	36 42 14.20	5474.1	14 06 05	Lieut. Birnie......	Lieut. Birnie......	One mile South Cañon Largo.
1874	San Juan River, Colo........	61 D	Sun...........	37 25 28.40	7776.7	15 01 00	Lieut. Marshall ...	Lieut. Marshall ...	At point trail to Del Norte leaves main fork.
1874	San Juan River, N. Mex	68 B	Polaris........ α Coronæ .... α Aquilæ	36 44 48.00	....	....	Lieut. Birnie	Lieut. Birnie......	Ten miles west of eastern boundary of Navajo reservation.
1874	San Juan River, Colo., Head of East Fork.	61 D	α Pegasi .... ε Pegasi .... Polaris........ α Aquilæ	37 23 06.40	9011.9	14 58 24	Lieut. Wheeler ... Lieut. Whipple ...	Lieut. Whipple ...	
1874	San Juan River, N. Mex....	69 A	ε Pegasi .... Polaris .... α Andromedæ .. α Lyræ	36 52 08.80	4808.4	14 10 31	Lieut. Whipple ...	Lieut. Whipple ...	

1874	San Juan River, N. Mex., (mouth of La Plata)	69 A	ε Pegasi Polaris α Andromedæ α Lyræ	36 45 59.80	5836.3	14 34 38	Lieut. Whipple	Lieut. Whipple	
1874	San Juan River, N. Mex., (mouth of Mancos)	69 A	α Lyræ ε Pegasi α Andromedæ Polaris	36 58 48.80	4721.2	14 00 31	Lieut. Whipple	Lieut. Whipple	
1873	San Juan mines, Colo	61 C	Sun Polaris α Arietis α Lyræ	37 50 19.90	9527.0	14 38 37	Lieut. Marshall	Lieut. Marshall	Howardsville.
1872	Santaquin, Utah	50	α Aquilæ Sun Polaris α Bootis	39 58 36.06	....	17 26 00	Lieut. Marshall	Lieut. Marshall	One mile north of.
1871	Saratoga Springs, Cal	66	Polaris α Coronæ Bor α Pegasi	35 41 04.53	263.6	15 05 00	Lieut. Lockwood	Lieut. Lockwood	
1872	Scipio, Camp near, Utah	50	Sun	39 10 50.23	5113.0	....	Lieut. Marshall	Lieut. Marshall	Four miles south of.
1872	Sevier River, head of East Fork, Utah.	59	Polaris α Lyræ α Cygni	37 30 05.23	8214.7	....	Lieut. Marshall	Lieut. Marshall	
1872	Sevier River Cañon, East Fork, Utah.	59	α Coronæ Polaris α Andromedæ	38 10 54.70	6081.2	....	Lieut. Marshall	Lieut. Marshall	
1872	Sevier River, East Fork, Utah.	59	α Aquilæ Polaris	37 39 51.73	7300.0	....	Lieut. Hoxie	Lieut. Hoxie	
1872	Sevier Lake, Camp near, Utah.	59	Polaris α Lyræ	38 49 48.60	4949.0	17 28 00	Lieut. Hoxie	Lieut. Hoxie	On bench, southwest side.
1872	Sevier Pass, Utah	50	α Aquilæ α Coronæ Polaris	39 32 33.90	4767.0	17 00 00	Lieut. Marshall	Lieut. Marshall	At west side, (mouth of cañon.)
1869	Schafer Spring, Nev	58	....	37 33 42.88	6186.0	16 10 45	Lieut. Lockwood	Lieut. Lockwood	
1872	Short Creek, Ariz	67	Sun Polaris	36 59 27.16	5022.7	....	Lieut. Marshall	Lieut. Marshall	
1869	Sheep Ranch, Cedar Valley, Nev.	58	Polaris α Aquilæ	38 13 48.00	7072.7	16 46 26	Lieut. Wheeler	Lieut. Wheeler	
1874	Simpson's Peak, Camp under, Colo.	61 C	Polaris α Coronæ Bor. α Pegasi α Aquilæ	37 40 37.70	10800.7	14 30 00	Lieut. Marshall	Lieut. Marshall	Peak 14055.9 feet.
1873	Skull Camp, N. Mex	84	Polaris α Lyræ α Andromedæ	33 00 55.00	5371.1	12 00 00	Lieut. Tillman	Lieut. Tillman	River Animas, N. Mex.
1872	Skumpah, Utah	67	Polaris Capella α Cygni	37 16 14.79	6142.1	....	Lieut. Marshall	Lieut. Marshall	One and one-half miles north of west of settlement.

Geographical positions, from sextant-observations, &c.—Continued.

Year.	Station.	Atlas-sheet No.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of needle. E.	Observer.	Computer.	Remarks.
				° ′ ″	*Feet.*	° ′ ″			
1869	Slough, Long Valley, Nev	49	Polaris Sun α Aquilæ	39 49 27.28	6215.6	16 59 55	Lieut. Wheeler Lieut. Lockwood	Lieut. Wheeler Lieut. Lockwood	
1874	Smith's Island, Colo	62 A	Polaris α Coronæ α Aquilæ α Pegasi	37 25 42.40	7868.0		Lieut. Wheeler	Lieut. Whipple	Near Fort Garland, Colo.
1869	Snake Creek, Nev	49	Polaris	39 00 05.28	5369.0	16 37 50	Lieut. Wheeler Lieut. Lockwood	Lieut. Wheeler Lieut. Lockwood	
1872	Snake Valley, Nev	49	Polaris α Bootis α Pegasi α Aquilæ	39 00 42.68		16 38 00	Lieut. Hoxie	Lieut. Marshall	
1873	Soldier's Fork, Utah	50	Jupiter α Bootis Polaris α Lyræ	39 59 15.10	5397.5		Lieut. Hoxie	Lieut. Tillman	
1873	Soldier's Fork, Head of, Utah	50	Jupiter α Bootis α Lyræ Polaris	39 55 06.50	6397.9		Lieut. Hoxie	Lieut. Tillman	
1873	South Fork S. Platte, Colo., near Weston's Pass.	52 D	Polaris α Bootis	39 04 27.70	10117.3	14 17 00	Lieut. Marshall	Lieut. Marshall	
1872	Spanish Forks, Utah, (camp near.)	50	Polaris Sun	40 05 10.80			Lieut. Marshall	Lieut. Marshall	
1869	Spring below Panacca, Nev.	58	Sun Polaris	37 45 27.07	4718.1	16 58 51	Lieut Wheeler	Lieut. Wheeler	
1872	Spring Valley, Nev	49	α Aquilæ α Bootis Polaris	39 45 24.14	6102.4		Lieut. Hoxie	Lieut. Marshall	
1869	Saint Thomas, near	66	Sun	36 26 33.43	1600.0	15 47 29	Lieuts. Wheeler and Lockwood.	Lieuts. Wheeler and Lockwood.	
1872	Sulphur Springs, Utah	59	Sun α Ophiuchi α Andromedæ Polaris	38 01 04.30	5400.0		Lieut. Marshall	Lieut. Marshall	
1873	Sunset Camp, Ariz	84	Polaris α Lyræ β Andromedæ	33 13 24.00	5276.2		Lieut. Tillman	Lieut. Tillman	

1871	Sunset Crossing, Ariz., (of Colorado Chiquito.)	76	Polaris γ Andromedæ α Aquilæ	34 59 41.70	4891.5	....	Lieut. Lockwood..	Lieut. Lockwood..	
1871	Sunset Tanks, Ariz	76	Polaris β Andromedæ α Lyræ	34 54 34.40	5797.2	....	Lieut. Lockwood..	Lieut. Lockwood..	
1871	Tanks at the Pines, Ariz	83	α Persei α Lyræ Polaris	33 42 31.30	5648.7	....	Lieut. Lockwood..	Lieut. Lockwood..	
1873	Tarryall Creek, near mouth of Rock Creek, Colo.	52 D	Polaris α Lyræ α Bootis	39 18 08.65	9006.3	14 49 00	Lieut. Marshall ...	Lieut. Marshall ...	
1873	Taylor River, Colo., at head of North Fork.	61 B	Polaris α Coronæ Bor	38 59 39.60	10209.0	....	Lieut. Marshall ...	Lieut. Marshall ...	
1873	Taylor River, Colo., on South Fork.	61 B	Polaris α Coronæ Bor	38 47 52.80	9686.3	....	Lieut. Marshall ...	Lieut. Marshall ...	Main tributary to Gunnison River.
1873	Thousand Lake Mountain, east base of, Utah.	59	Jupiter Polaris α Lyræ α Bootis α Serpentis	38 28 40.90	9248.4	....	Lieut. Hoxie	Lieut. Tillman	
1873	Three Water Pockets, Utah	59	Polaris α Lyræ α Bootis	37 44 49.70	4673.1	....	Lieut. Hoxie	Dr. Kampf	
1873	Tierra Amarilla, N. Mex	69 B	Polaris Markate	36 41 29.20	7466.1	13 42 26	Lieut. Marshall ...	Lieut. Marshall ...	
1874	Nutritas Plaza	69 B	α Persei Polaris α Cygni α Lyræ	36 41 29.40	....	....	Lieut. Wheeler ...	Lieut. Whipple ...	
1873	Timber Cañon, Utah	50	Sun α Leonis α Bootis Polaris	39 44 43.15	7978.7	....	Lieut. Hoxie	Lieut. Tillman	
1873	Topographical Station and Camp, N. Mex.	76	Polaris α Aquilæ α Pegasi α Ophiuchi	34 56 38.00	6291.9	13 58 12	Lieut. Hoxie......	Lieut. Tillman	Near Ojo Calie ıte.
1871	Truxton Springs, Ariz	75	Sun Polaris	35 24 52.51	3885.5	....	Lieut. Lockwood.. Lieut. Lyle	Lieut. Lockwood..	
1873	Tule Springs, N. Mex	76	Polaris α Aquilæ α Coronæ α Pegasi	34 31 30.30	5924.7	13 36 23	Lieut. Hoxie	Lieut. Tillman	
1873	Tulerosa, Fort, N. Mex	83	Polaris α Aquilæ α Ophiuchi α Pegasi	33 52 47.90	6740.4	13 17 42	Lieut. Hoxie	Lieut. Tillman	Old fort.
1874	Tunicha Creek	68 D	Polaris α Pegasi α Andromedæ	36 13 41.60	5510.0	14 00 41	Lieut. Birnie......	Lieut. Birnie......	On mesa, between Tunicha and Vaca Creeks.

Geographical positions, from sextant-observations, &c.—Continued.

Year.	Station.	Atlas-sheet No.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of needle. E.	Observer.	Computer.	Remarks.
				° ′ ″	*Feet.*	° ′ ″			
1869	Vegas Wash, Nev., (mouth of.)	66	Polaris α Aquilæ	36 06 34. 85	....	16 01 05	Lieut. Wheeler Lieut. Lockwood	Lieut. Wheeler Lieut. Lockwood	
1874	Vermejo Creek, N. Mex	70 A	Sun	36 41 30. 60	6249. 6	14 30 00	Lieut. Blunt	Lieut. Blunt	Crossing Santa Fé and Trinidad roads.
1871	Virgin Hill, Nev	66	Polaris α Coronæ Bor α Pegasi	36 37 45. 89	....	....	Lieut. Wheeler Lieut. Lockwood	Lieut. Wheeler Lieut. Lockwood	
1872	Virgin River, Utah, North Fork.	59	Polaris α Pegasi α Aquilæ α Herculis	37 21 47. 37	....	....	Lieut. Hoxie	Lieut. Hoxie	
1872	Virgin River, Utah, Camp S.	67	Polaris α Lyræ α Andromedæ	37 08 06. 60	....	15 29 00	Lieut. Hoxie	Lieut. Hoxie	
1869	Walker's Ranch, Nev	40	Polaris	40 43 50. 67	5145. 9	....	Lieut. Wheeler	Lieut. Wheeler	
1872	Warm Creek, Utah	67	Polaris α Persei α Lyræ	37 03 23. 20	4008. 9	....	Lieut. Marshall	Lieut. Marshall	On trail[1] to El Vado de los Padres.
1873	Water-Hole, N. Mex	83	Polaris α Aquilæ α Ophiuchi α Pegasi	33 12 49. 30	5612. 9	13 30 00	Lieut. Hoxie	Lieut. Tillman	
1873	Water-Pocket, Utah	59	Polaris α Serpentis α Lyræ α Bootis	37 29 09. 80	3559. 6	15 48 00	Lieut. Hoxie	Dr. Kampf	East of Escalante River.
1873	Water-Pocket, Utah, (on ridge near.)	60	Polaris α Lyræ α Bootis	37 27 28. 70	4781. 2	15 29 60	Lieut. Hoxie	Dr. Kampf	East of Escalante River.
1873	Welcome Creek, Utah	59	Sun Polaris α Serpentis α Lyræ	37 34 13. 30	3640. 9	15 07 00	Lieut. Hoxie	Dr. Kampf	Camp.
1869	West Point, Nev	66	Sun Polaris	36 40 33. 56	1754. 0	15 18 59	Lieut. Wheeler Lieut. Lockwood	Lieut. Wheeler Lieut. Lockwood	Camp.
1873	Wet Mountain Valley, Colo	62 A	Sun Polaris	38 02 22. 60	8000. 0	14 20 00	Lieut. Marshall	Lieut. Marshall	Near Garnier's ranch.
1873	Wet Camp, N. Mex	84	Polaris β Andromedæ α Lyræ	33 27 43. 00	6016. 5	....	Lieut. Tillman	Lieut. Tillman	Camp.

1869	Union Peak	58	Sun	38 58 23.01	13036.0	....	Lieut. Wheeler	Lieut. Wheeler	Summit of Peak.
1873	Price River, Utah, (branch of North Fork.)	50	Jupiter α Bootis · Polaris α Lyræ	39 55 28.80	7911.0	....	Lieut. Hoxie	Lieut. Tillman	
1873	Price River, (bluff west of junction of North and South Forks,) Utah.	50	α Bootis Polaris α Lyræ α Ursæ Majoris γ Ursæ Majoris	39 48 11.30	7088.0	....	Lieut. Hoxie	Lieut. Tillman	Camp.
1869	Wild Hop Creek, (Pioneer Cañon, Nev.)	58	Polaris α Aquilæ	38 23 16.80	6928.0	15 59 29	Lieut. Wheeler	Lieut. Wheeler	
1869	Willow Creek, Nev	49	Polaris α Aquilæ	40 31 13.91	5518.9	17 27 07	Lieut. Wheeler Lieut. Lockwood	Lieut. Wheeler Lieut. Lockwood	
1873	Wingate, Fort, N. Mex	77 A	Polaris α Ophiuchi α Pegasi α Aquilæ α Coronæ Bor.	35 28 49.47	6982.1	14 51 27	Lieut. Hoxie L. Nell	Lieut. Tillman L. Nell	Flagstaff.
1871	Young's Spring, Ariz	75	α Pegasi α Ophiuchi Polaris	35 32 04.28	... ...	....	Lieut. Lockwood	Lieut. Lockwood	
1873	Yucca Camp, N. Mex	89	Polaris α Andromedæ α Lyræ	32 18 48.00	4374.0	12 37 42	Lieut. Tillman	Lieut. Tillman	
1875	Station A, Cal	65 D	α Bootis α Cygni α Coronæ α Pegasi β Ophiuchi Polaris α Aquilæ	36 4 44.92	1232.8	15 10.36	Lieut. Birnie	Lieut. Birnie	Base-station, Panamint Valley, Cal.
1875	Alamo Gordo, N. Mex	78 A	α Aquilæ α Arietis α Pegasi Polaris	34 48 45.70	4863.4	....	Lieut. Morrison	Lieut. Birnie	Drain of.
1875	Animas Valley, Colo	61 C	α Aquilæ Polaris	37 21 19.10	6561.3	....	Lieut. Marshall	Lieut. Birnie	
1875	Cañon Pajarito, N. Mex	78 A	α Aquilæ α Arietis α Pegasi Polaris	34 59 44.20	5099.0	....	Lieut. Morrison	Lieut. Birnie	
1875	Bear Creek, Cal	65 C	α Lyræ ε Pegasi Polaris	35 56 59.30	6145.3	....	Dr. Kampf	Lieut. Birnie	Head of.
1875	Bennett's Well, Cal	65 D	α Coronæ α Pegasi α Aquilæ Polaris	36 09 49.19	—5.8	....	Lieut. Birnie	Lieut. Birnie	Death Valley, Cal., below sea-level.
1875	Burrough's Park, Colorado	61 C	Sun	37 56 27.90	10878.2	....	Lieut. Marshall	Lieut. Birnie	

Geographical positions, from sextant-observations, &c.—Continued.

Year.	Station.	Atlas-sheet No.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of needle. E	Observer.	Computer.	Remarks.
				° ′ ″	*Feet.*	° ′ ″			
1875	Cartago, Cal	65 C	β Ceti Polaris	36 18 35.20	3589.0	....	Lieut. Birnie	Lieut. Birnie	Owen's Lake. Time by equal altitudes of meridian-star.
1875	Cerro Cuervo, N. Mex	78 A	α Aquilæ α Arietis α Pegasi Polaris	35 07 36.50	4882.5	....	Lieut. Morrison	Lieut. Birnie	
1875	Cerro Cueva, N. Mex	78 A	α Aquilæ α Arietis α Pegasi Polaris	35 10 35.60	5538.4	....	Lieut. Morrison	Lieut. Birnie	Foot of.
1875	Cerro Gordo Landing, Cal	65 D	α Coronæ α Pegasi α Aquilæ Polaris	36 27 36.55	3656.1	15 18 42	Lieut. Birnie	Lieut. Birnie	
1875	Cherry Creek, Colo	69 A	α Coronæ α Pegasi α Aquilæ Polaris	37 18 31.20	7449.4	....	Lieut. Marshall	Lieut. Birnie	
1875	Cimarron Seco, N. Mex	70 B	α Aquilæ α Arietis α Pegasi Polaris	36 50 08.70	....	....	Lieut. Morrison	Lieut. Birnie	
1875	Laguna, Colo	77 B	α Aquilæ α Arietis α Pegasi Polaris	35 13 01.80	6999.8	....	Lieut. Morrison	Lieut. Birnie	
1875	Cottonwood Cañon, Cal	65 B	α Coronæ α Pegasi α Aquilæ Polaris	36 31 46.88	2992.7	....	Lieut. Birnie	Lieut. Birnie	
1875	Cottonwoods, Cal	73 D	α Lyræ α Bootis α Serpentis Polaris	34 48 01.78	2487.8	....	Lieut. Birnie	Lieut. Birnie	Mojave River.
1875	Egan's Falls, Cal	65 D	α Bootis α Cygni β Ophiuchi Polaris	36 19 42.75	....	....	Lieut. Birnie	Lieut. Birnie	Darwin Cañon.

1875	Esteros, N. Mex	78 A	α Aquilæ α Arietis α Pegasi Polaris	35 09 20.20	5319.8	....	Lieut. Morrison	Lieut. Birnie	Laguna de los.
1875	Forks Los Angeles and Caliente roads, Cal.	73 A	β Pegasi α Ceti β Ceti Polaris	35 07 49.00	2752.0	14 47.42	Lieut. Birnie	Lieut. Birnie	Near Tehachipi Pass.
1875	Old Fort Tejon, Cal	73 A	α Bootis α Cygni α Ophiuchi Polaris	34 52 03.40	3245.7	14 54.30	Lieut. Wheeler	Lieut. Birnie	
1875	Furnace Creek, Cal	65 D	α Coronæ α Pegasi α Aquilæ Polaris	36 26 21.50	405.1	15 41.30	Lieut. Birnie	Lieut. Birnie	One and a quarter mile from mouth.
1875	Glendale, Cal	65 C	α Coronæ ε Pegasi α Aquilæ Polaris	36 29 50.50	9923.5	15 41.18	Dr. Kampf	Lieut. Birnie	
1875	Glenville, Cal	65 C	α Andromedæ ε Pegasi Polaris	35 43 18.10	3094.3	....	Dr. Kampf	Lieut. Birnie	
1875	Granite Wells, Cal	73 B	α Lyræ α Bootis α Serpentis Polaris	35 22 31.80	4015.2	15 06.30	Lieut. Birnie	Lieut. Birnie	Near Pilot Knob.
1875	Huntington's, Cal	73 D	α Lyræ α Bootis α Serpentis Polaris	34 32 16.08	2898.6	....	Lieut. Birnie	Lieut. Birnie	Mojave River.
1875	Hunter's Ranch. Cal	65 B	α Coronæ α Pegasi α Aquilæ Polaris	36 33 40.85	6274.7	15 44.42	Lieut. Birnie	Lieut. Birnie	Jackass Spring.
1875	Juan de Dios, N. Mex	78 A	α Aquilæ α Arietis α Pegasi Polaris	34 48 45.70	4819.5	....	Lieut. Morrison	Lieut. Birnie	Head of Arrojo.
1875	Kern River, Cal	65 C	α Coronæ ε Pegasi α Aquilæ Polaris	36 23 50.20	9238.8	15 37 48	Dr. Kampf	Lieut. Birnie	Branch of.
1875	Kern River, Cal	65 C	α Coronæ ε Pegasi α Aquilæ Polaris	36 21 38.80	8917.1	15 51 48	Dr. Kampf	Lieut. Birnie	Branch of.
1875	Kern River, Cal	65 C	α Andromedæ α Lyræ α Pegasi Polaris	36 20 37.90	6442.1	16 45 48	Dr. Kampf	Lieut. Birnie	Branch of.

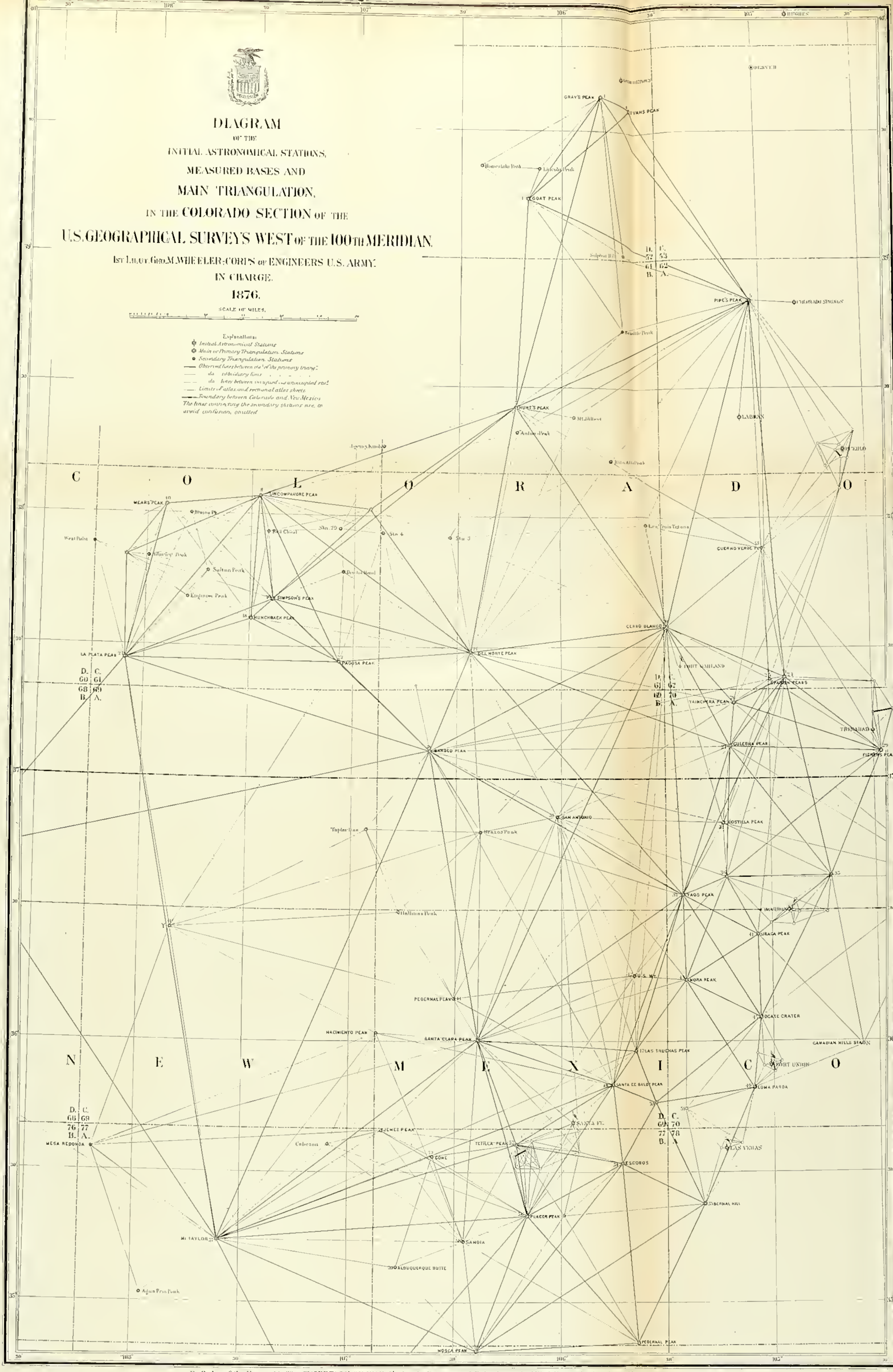
Geographical positions, from sextant-observations, &c.—Continued.

Year.	Station.	Atlas-sheet No.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of needle. E.	Observer.	Computed.	Remarks.
				° ′ ″	*Feet.*	° ′ ″			
1875	Kern River, Cal	65 C	α Lyræ α Andromedæ ε Pegasi Polaris	36 10 29. 10	7578. 8	....	Dr. Kampf	Lieut. Birnie	West Fork.
1875	Kernville, Cal	65 C	α Andromedæ α Lyræ ε Pegasi Polaris	35 42 3. 30	2707. 7	16 43 00	Dr. Kampf	Lieut. Birnie	Near post-office.
1875	La Motte's, Cal	65 C	α Coronæ α Aquilæ Polaris	35 53 15. 80	6460. 8	15 51 00	Dr. Kampf	Lieut. Birnie	
1875	Lime Creek, Colo	61 C	Sun	37 42 28. 80	9581. 2	....	Lieut. Marshall	Lieut. Birnie	
1875	Little Lake, Cal	65 C	α Andromedæ α Lyræ ε Pegasi Polaris	35 55 56. 96	3086. 4	14 45 18	Lieut. Birnie	Lieut. Birnie	
1875	Lone Pine, Cal	65 A	α Lyræ ε Pegasi Polaris	36 35 58. 68	3810. 1	15 19 42	Lieut. Birnie	Lieut. Birnie	North Plaza.
1875	Los Angeles, Cal	73 C	α Lyræ α Bootis α Ursæ Majoris α Lyræ Polaris	34 03 34. 41	325. 6	14 30 30	Lieut. Wheeler and Lieut. Birnie.	Lieut. Birnie	Rendezvouz Camp.
1875	Menatchey Valley, Cal	65 C	α Coronæ ε Pegasi α Aquilæ Polaris	36 12 37. 20	9503. 2	15 16. 24	Dr. Kampf	Lieut. Birnie	
1875	Nadean's Station, Cal	65 C	ε Pegasi α Ceti β Ceti Polaris	35 22 10. 11	2394. 4	....	Lieut. Birnie	Lieut. Birnie	Red Rock Cañon.
1875	Oasis Valley, Nev	65 B	α Coronæ α Pegasi α Aquilæ Polaris	36 53 02. 15	3085. 2	15 20. 24	Lieut. Birnie	Lieut. Birnie	Springs, south end of.
1875	Olancha, Cal	65 C	α Bootis α Cygni β Ophiuchi Polaris	36 16 51. 79	....	14 54. 12	Lieut. Birnie	Lieut. Birnie	Post-office.

1875	Olancha Peak, Cal	65 C	α Coronæ α Pegasi α Aquilæ Polaris	36 14 44.20	....	....	Dr. Kampf	Lieut. Birnie	Foot of.
1875	Olancha Peak, Cal	65 C	α Coronæ ε Pegasi α Aquilæ Polaris	36 16 12.70	8743.2	16 07.18	Dr. Kampf	Lieut. Birnie	Northwest side of.
1875	Oso Meadows, Cal	65 C	α Andromedæ α Lyræ ε Pegasi Polaris	36 11 48.60	5981.7	15 45.00	Dr. Kampf	Lieut. Birnie	
1875	Pino, N. Mex	78 A	α Aquilæ α Arietis α Pegasi Polaris	35 16 33.40	5504.4	....	Lieut. Morrison	Lieut. Birnie	West mesa.
1875	Rio Grande, Colo	61 C	α Andromedæ α Aquilæ Sun Polaris	37 42 37.00	11660.3	....	Lieut. Marshall	Lieut. Birnie	Where the Ute trail comes down.
1875	Rule Creek, Colo	62 D	α Aquilæ α Arietis α Pegasi Polaris	37 54 17.00	....	....	Lieut. Morrison	Lieut. Birnie	Camp 110.
1875	Rule Creek, Colo	62 D	α Aquilæ α Arietis α Pegasi Polaris	37 35 09.00	....	....	Lieut. Morrison	Lieut. Birnie	Camp 109.
1875	Saguache, Colo	61 D	α Cygni α Bootis Polaris	38 04 58.90	7723.1	....	Lieut. Marshall	Lieut. Birnie	
1875	Salt Wells, Cal	65 D	α Coronæ α Pegasi α Aquilæ Polaris	36 44 16.15	117.1	....	Lieut. Birnie	Lieut. Birnie	Death Valley.
1875	San Augustin, N. Mex	78 A	α Lyræ ε Pegasi Polaris	35 30 35.30	6002.0	....	Lieut. Morrison	Lieut. Birnie	Las Valles de.
1875	Say-qui-ta, Cal	65 B	Equal altitude ☉'s upper limb. ☉'s upper limb.	36 55 01.50	5553.2	....	Lieut. Birnie	Lieut. Birnie	Springs.
1875	Silver Springs, Cal	65 D	α Coronæ α Pegasi α Aquilæ Polaris	36 14 02.50	4110.2	....	Lieut. Birnie	Lieut. Birnie	
1875	Stone's Ranch, N. Mex	78 A	α Aquilæ α Arietis α Pegasi Polaris	35 21 43.30	....	....	Lieut. Morrison	Lieut. Birnie	

Geographical positions, from sextant-observations, &c.—Continued.

Year.	Station.	Atlas-sheet No.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of needle. E.	Observer.	Computer.	Remarks.
				° ′ ″	*Feet.*	° ′ ″			
1875	Tehachipai Valley, Cal	73 A	α Andromedæ α Lyræ α Pegasi Polaris	35 06 49.80	3830.6	14 12.00	Lieut. Whipple	Lieut. Birnie Lieut. Macomb	
1875	Trout Meadows, Cal	65 C	α Coronæ α Pegasi α Aquilæ Polaris	36 01 58.20	5998.3	16 28.48	Dr. Kampf	Lieut. Birnie	
1875	Twenty Mile Station, Cal	65 D	α Bootis α Cygni β Ophiuchi Polaris	36 01 10.40	......	....	Lieut. Birnie	Lieut. Birnie	Shepherd's Cañon.
1875	Uhl's Ranch, Cal	65 C	α Andromedæ α Lyræ ε Pegasi Polaris	35 52 09.20	2661.5	....	Dr. Kampf	Lieut. Birnie	
1875	Unaweep, Colo	61 C	α Aquilæ Polaris	38 07 48.50	7475.8	....	Lieut. Marshall	Lieut. Birnie	
1875	Ute Creek, N. Mex	70 C	α Aquilæ α Arietis α Pegasi Polaris	36 16 31.50	......	....	Lieut. Morrison	Lieut. Birnie	Upper.
1875	Walker's Creek, Cal	65 C	α Coronæ α Pegasi α Aquilæ Polaris	35 45 17.90	3237.5	....	Dr. Kampf	Lieut. Birnie	
1875	Weldon, Cal	65 C	α Bootis α Andromedæ α Lyræ α Aquilæ ε Pegasi Polaris	35 40 03.70	2716.9	16 13.18	Dr. Kampf	Lieut. Birnie	Nichols's Ranch.
1875	Whitney, Cal	65 C	α Coronæ ε Pegasi Aquilæ Polaris	36 29 30.50	11051.2	15 34.48	Dr. Kampf	Lieut. Birnie	Foot of mount.
1875	Whitney Meadows, Cal	65 C	Andromedæ α Lyræ ε Pegasi Polaris	36 25 44.66	9371.4	....	Lieut. Birnie	Lieut. Birnie	



By Order of the Honorable The SECRETARY OF WAR, Under the Direction of Brig. Gen. A. A. HUMPHREYS, Chief of Engineers, U.S. Army.

1875	Wild Rose Spring, Cal	65 D	α Coronæ .... α Pegasi .... α Aquilæ .... Polaris	36 15 54.37	4683.4	15 19.12	Lieut. Birnie	Lieut. Birnie .....
1875	Willow Spring, Cal	73 A	α Andromedæ .. α Lyræ .... ε Pegasi .... Polaris	34 52 38.70	2530.8	....	Lieut. Whipple ...	Lieut. Birnie ..... Lieut. Macomb ...

GEODETIC AND TOPOGRAPHICAL.

Measured and developed bases were laid out at Los Angeles, Weldon, and Panamint Valley, in the California section. None were found necessary or requisite in the Colorado section.

The sketch herewith shows the progress made in the development and number of the secondary triangulation belts in the Colorado section, and will at an early day be supplemented by a map showing the development of triangles from the Los Angeles base to the eastward. Triangulation observations have been made by each one of the moving field-parties over large areas in California, Nevada, Colorado, and New Mexico.

A list of geographical positions, other than those given in the present report, will appear in the list of astronomical positions in Volume II; other positions in the appendix of part second, Volume II, giving altitudes of prominent positions, and the remainder in Volume I of the survey publications.

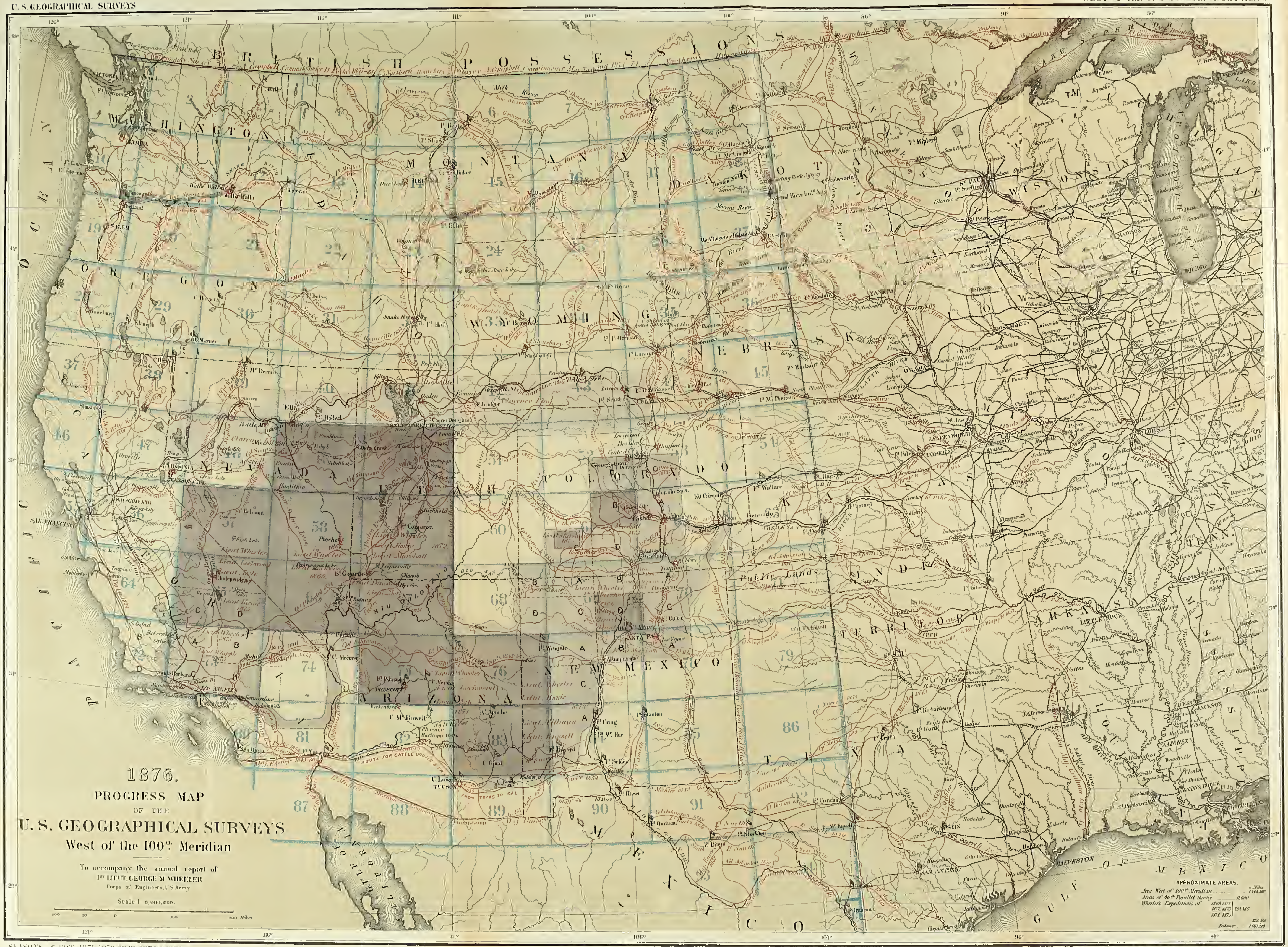
The areas in Colorado, New Mexico, California, Nevada, and Arizona were occupied in accordance with the project submitted to and approved by the Chief of Engineers and Secretary of War.

Many connections have been made with the stakes and other marks of the public-land surveys. The degree of progress in topographical accuracy of delineation is one of the notable features of the year. The outgrowth from the surveys of the parties under Lieutenant Marshall admitted of the construction of a special sheet of the San Juan mining region, on a scale of 1 inch to 2 miles, being an independent map of one-fourth the area of the southwest quarter of atlas-sheet 61, which area has also been reproduced and published, on a scale of 1 inch to 4 miles, during the year. The mountainous portions of the country having intricate drainage areas are now all delineated and published, upon a scale of 1 inch to 4 miles, while plateau and semi-desert areas are drawn upon a scale of 1 inch to 8 miles. The larger scales are also susceptible of reduction to the uniform scale proposed for the atlas of the entire section west of the one-hundredth meridian. Many monuments have been built, and the positions occupied are susceptible of identification and further use in connection with a extended scheme of triangulation, or for the purpose of fixing accurately the positions of minor points that may spring into importance in succeeding years.

ROUTES OF COMMUNICATION.

Tables of distances and road-profiles have been computed over the principal traveled routes and important trails in those portions of Colorado and New Mexico, Southern Califorinia, Utáh, and Arizona over which the surveys have extended. These are based upon odometer and barometer measurements of the survey. In addition to the simple distances, the facilities for camping are noted.

Such tables, together with material gathered in the field-season of 1876, will furnish the basis of an extended set of tables, and supply to a great extent a need long felt for authoritative distances over a country where the distribution of water is such that the traveler needs to know where he may find wood, water, and grass or grain to guide him in his selection of routes and camps. These tables, with profiles of the more important routes, it is proposed to publish in separate form at an early day, as stated in report of last year.



SEASONS of 1869, 1871, 1872, 1873, 1874 & 1875

1st Lieut. Geo. M. Wheeler, Corps of Engineers, U.S. Army in Charge

EXPLANATIONS.

Index Areas to Atlas Maps.

Primary Astronomical Stations completed.

Points proposed for primary Astronomical Stations.

Atlas Sheets published

Areas of which maps are in course of preparation

Areas embraced by the Exploration of the 40th Parallel (Clarence King.)

Lines of Expeditions, possessing Explorations and Surveys, conducted by "Officers of the Line," "Corps of Topographical Engineers," and "Corps of Engineers," U.S. Army.

Military Post

Existing Telegraph Lines

Proposed Telegraph Lines

BY ORDER OF THE HONORABLE THE SECRETARY OF WAR.

UNDER THE DIRECTION OF BRIG. GEN. A. A. HUMPHREYS, CHIEF OF ENGINEERS U.S. ARMY.

PROGRESS-MAP.

The progress-map herewith shows by colors the different stages of prosecution of the map results. Appropriations being small and the season limited, only a small expedition comparatively can be put in the field.

ITINERARY.

The following is a brief *résumé* of the result of such observations bearing upon the characteristics and natural resources of the section visited as I was able to make while in charge of main party No. 1 of the California section during the field-season of 1875.

The routes pursued were along the regularly-traveled road from Caliente to Los Angeles, through Tehachipi Pass, across the northwestern arm of the great outlier of the Mohave Desert, via Elizabeth Lake, &c., from Los Angeles to Santa Monica and Wilmington on the coast; thence via Cahuenga Pass, through San Fernando Valley and the valley of Santa Clara, to old Fort Tejon and its neighborhood, and thence by the southern end of Tulare Valley to Caliente. Besides the routes above mentioned, that from Los Angeles, via Cajon Pass to Camp Mohave, had been traversed in the latter part of the year 1868, from which a somewhat clear idea of the characteristics of that portion of Southern California adjacent to these lines could be formed.

The results of the operations of the other parties of the California section of 1875 are set forth in the various reports submitted by the executive officers. (See reports of Lieutenants Bergland, Birnie, and Whipple, also that of Dr. Oscar Loew.)

Los Angeles is at present the principal point for commercial exchange in the county of that name, and is favorably located in the center of a part of the somewhat level arable territory south of the passes through the Southern Sierras, west of the coast range, forming a basin of considerable dimensions most favored by nature of any of the so far developed portions of Southern California.

Its outgoing connections are by the Southern Pacific Railroad north to the San Fernando Mountains, through which a tunnel (being a function of said road) is being constructed, that, upon completion, will connect it with the southern terminus of that branch of the same road now traversing Tulare Valley, and through Tehachipi Pass to the arm of the desert, thence via Soledad Pass to the northern entrance of the San Fernando Tunnel, thus making a connection that, once accomplished, will stand as a landmark of the skill and energy of these railway constructions.

The southern section of this same road is being built via San Gorgonio Pass toward the desert, in direction of Fort Yuma, with great vigor. Other branches of the same corporation lead direct to Wilmington, with a branch to Anaheim, being part of the route bordering upon the coast already reconnoitered to the southward as far as San Diego. The Los Angeles and Camp Independence Railroad, under the auspices of a corporation formed in pursuance of the laws of the State of California, is built from Santa Monica a point a little south of west of Los Angeles to this city, with the expectation of being pushed eastward through the Cajon Pass in the direction of the mining-districts in vicinity of Death Valley and Camp Independence.

It will be seen that the outgoing connections from Los Angeles are plentiful, and that it is likely to become a prominent point upon the

through line of transit so soon as the Southern Pacific shall have connected its line of road from San Francisco to the Colorado River. The distance from Los Angeles to Santa Monica by rail is 12½ miles, and at the latter point a little town has sprung up, consequent upon the advantages of commercial relations, transit of supplies, &c., from the north, the evidences of a good beach, convenient as a resort for the people of this section and such others as may be desirous of taking advantage of the more genial climate of this part of the California coast. Wilmington, until lately the point from which military supplies have been forwarded into Arizona, is at the head of a little lagoon or estuary not navigable for large crafts, at the lower part of which estuary, by means of a breakwater lately built by and under the direction of officers of the Engineer Corps, after the plans of Lieut. Col. B. S. Alexander, Corps of Engineers, and in charge of Maj. G. H. Mendell, with Lieut. Clinton B. Sears as assistant, has been partially opened for navigation, so that several landings may be effected near the old town of San Pedro, to which it is understood the line of railroad will be carried at an early day.

The route outward from Los Angeles was via the Cahuenga Pass leading into the San Fernando Valley, or plains, as they have been termed, a large grazing section, on the stage-road leading hence to Santa Barbara, an oasis in its way facing the broad valley. The buildings lie nestled in groves of magnificent oaks, the soil itself being a heavy, rich, dark loam, evidently capable of producing most luxuriant crops, could sufficient water for irrigating purposes be had. It is not unlikely that, in some of the ravines leading back into the foot-hills, the search for artesian water would prove successful, and that it would be found sufficient for the successful irrigation of a large part of the valley.

Across the valley brings us to the old Mission of San Fernando, which was described by the earlier travelers to this region, near which has been built a little valley town, by the name of San Fernando, at the present terminus of the line of rail leading from Los Angeles to this point. The remains of the old conduits for irrigation and other hydrographic purposes, made by the Jesuit fathers with the aid of Indian labor, are still visible, and attest the degree to which agriculture was carried in those days by this rude kind of labor, guided by the padres, and it is not difficult, after a closer inspection of the remains, to believe in the tales of wonderful fertility of the fields well watered and covered with foliage, and of the large herds of cattle and sheep reputed to have been the property of these early missionaries.

The whole valley of San Fernando is one level plain of large extent, of a strong, naturally productive soil, as is evinced by the luxuriant growth of herbage of varying size, that needs only the advent of a proper amount of water to bring it into the condition of a garden. Much water falls in the neighboring mountains, but it mostly passes out of sight, except in the seasons of freshet, and under the beds of alluvium to the drainage of Los Angeles River.

The Big and Little Tujunga and Pacoima Creeks are all streams of considerable size, varying in different seasons, but soon sink upon reaching the plain. The storage of these waters in the vicinity of the mouths of the cañons through which they debouch would serve to act as reservoirs sufficient in size and extent to hold the necessary supply to make fertile all the outlying lands, of which there are at least 150,000 acres cultivatable by irrigation. In this valley alone were seen only two ranches, where but a few acres of land are cultivated. Fields of wheat barley, and oats were noted, lying between the two, where, without

the aid of irrigation, crops have been produced in favorable years. The route from San Fernando north takes one across a range of this name into Santa Clara Valley, the axis of which, bearing north in its eastward course, connects the coast with the desert and the interior section leading toward the Colorado River. The Soledad Pass at its head, the summit of which is 3,332 feet above the level of the sea, is the lowest connection between this portion of the southern coast of California and the interior, being the lowest summit of the main coast range, and, indeed, the lowest summit found between the drainage reaching the Pacific from the Columbia and the basins north of the fortieth parallel to the Mexican border upon the Pacific slope. It is unfortunate that no good harbor exists near this point from the Pacific coast. Were such the case, we might easily expect to see another large city like San Francisco spring up at an early day.

Agricultural facilities are being utilized; new mines in the interior are discovered from time to time; grazing has long been notable in this section of the State, and as its climatic status is becoming better understood, it, with other points of interior California, are likely rapidly to advance and become from year to year more thickly settled.

The route to the northward crosses the divide near the vicinity of Elizabeth Lake; thence, continuing northward, follows the edge of the northwestern arm of Mohave Desert, reaching, via Lievre ranch, the southern end of the Canada de las Uvas, or one of the passes between the Colorado drainage and that of the Sacramento via the great Tulare Valley. The profile of this pass is much gentler than that of Tejon or Tehachipi Pass, and could be made use of for a railroad leading to the Pacific coast near the thirty-fifth parallel, the same to be carried northward, with a terminus at San Francisco. It is believed that no practicable profile so far has ever been found for a railroad north of the Santa Clara Valley, because of the impracticable ridges of the coast range immediately encountered in going north. This fact may prove of consequence in connection with some later railroad undertaking, for a pass once entered and held determines for the parties in possession that no near competition can be effected, as no parallel road could naturally, with any reasonable expense, be constructed and maintained.

The springs and little creeks running part or all the year on the southern side of this cañon have, of late years, as is reported by settlers in this region, grown less and less, until many of them have entirely disappeared.

Lievre ranch itself, an old Spanish grant, reputed to have been one of the finest in this section of the country, has along its southeastern borders become entirely covered with beds of drifting sand, covering up and killing out the annual grasses of this region, and adding to the area of desolation commanded by the outlying desert.

Old Fort Tejon, once the scene of military operations against the Indians of this quarter, was reached during our trip, where we found the old adobe buildings still standing in fair repair. It is on a level spot, but geographically not well situated, being in the jaws of a side cañon entering the main cañon of the creek upon which the post was situated, from which the lives of the garrison and the safety of the animals could at any time have been easily jeopardized. The elevation, being 3,245.7 feet above the level of the sea, afforded an agreeable climate as compared with that in the great Tulare Valley, that lies to the northward, the elevation of which (Bakersfield) is 465 feet. The reservation has now passed into the hands of private parties, and is used for stock-raising.

The outlying mountains show mineral wealth, gold, silver, lead, and antimony, although little prospecting and less developing has been done. It may be said that very few of the mountain ranges in the interior of California have been fully and fairly prospected. Prospecting-parties usually traverse well-known routes or trails, and have in view certain objective points, to which their attention is entirely directed. Failing in good results there, they usually return to their old stamping-ground and wait for an occasion to call them in another direction. It need not astonish any one to hear of most remarkable mineral discoveries in the coast range and Sierra Nevada for many years to come, or if further developments upon mining-claims taken up heretofore and abandoned as worthless shall prove the contrary. The creek, the main source of which is the one that flows by old Fort Tejon, thence down the cañon toward the great plains, and through which until the railroad had reached Caliente, on Tehachipi Creek, the stage-line to the south had usually passed. The road from the mouth of this creek to Caliente passes a little north of Tejon ranch, and likewise of the old Indian reservation, which has now passed into private hands, and traverses the passes of a series of foot-hills of remarkably pleasant contour, well grassed, and covered irregularly with copses of oak and pine. Although brown and seared at the date of our visit, still the landscape presented was one not easily to be forgotten.

Buena Vista Lake, lying in the great Tulare plain in front of us, acts as the reservoir of Kern River, evidently like Lake Tulare, which during seasons of great rain-fall and the spring melting of snows overflows its banks. Tulare Lake, however, as a reservoir will reach approximately to 100 square miles in size, and loses by evaporation throughout the months of the year characterized by non-precipitation or by a minimum rain-fall all that is obtained from the regular river source of supply that reaches it. I am informed that it was found by Maj. R. M. Brereton, late of the royal engineers, that the average amount of annual evaporation from its surface was approximately 6 feet. The question of irrigation has of late years been agitated in the State of California by the gentleman to whom allusion has been made and others, and his aid is likely to promote the same by his engineering skill and experience in works of this class in India. The lines of proposed canals and opportunities for utilizing water-supply gathered in the various basins, especially those upon the western flanks of Sierra Nevadas, can be found in the report of the commissioners upon irrigation of the great valleys of of California. (See Executive Document No. 290, 43d Cong., 1st sess.)

NATURAL RESOURCES.

As time has permitted, a number of the assistants have been employed in laying down upon the preliminary maps and in tabulating the areas whose natural resources permit of use for agricultural, mining, grazing, and timber purposes as in contradistinction to those absolutely worthless, being arid and barren. The table, with remarks, is submitted herewith, and it is proposed to gather complete statistics upon these important points in all the areas traversed hereafter, and as time shall permit to make comparison of larger areas after material shall have been worked up in connection with the surveys of prior years. A number of colored maps, graphically illustrating the same, can then be prepared.

In addition to the determination of the natural resources of the sec-

tion surveyed, as denoted by its superficial area, it is proposed, as far as practicable with the force at the disposal of the officer in charge, to have noted the prominent streams, lakes, and springs, the area of basin-drainage in which they are situate, with an accurate delineation of the perimeters of the same, and, when practicable, the determination of the rain-fall for a period, or annually, when it shall have been observed, and further, what bearing this practical information shall have upon the subject of irrigation by canals, reservoirs, or artesian wells within any of the basins visited.

Atlas-sheet number.	Total area.	Agricultural, irrigable, and arable.	Timber.	Grazing.	Barren.	Land available for agriculture, timber, or grazing.	Remarks.
52 (D.) Central Colorado.	4,224.8 square miles. 2,703,872 acres.	Zero.	57 per cent. 2,408 square miles. 1,541,207 acres.	22 per cent. 929 square miles. 594,852 acres.	21 per cent. 887 square miles. 567,813 acres.	79 per cent. 3,337.8 square miles. 2,136,059 acres.	
61 (B.) Central Colorado.	4,274.8 square miles. 2,735,872 acres.	3 per cent. 128 square miles. 82,076 acres.	61 per cent. 2,608 square miles. 1,668,881 acres.	17 per cent. 727 square miles. 465,092 acres.	19 per cent. 812 square miles. 519,817 acres.	81 per cent. 3,462 square miles. 2,216,055 acres.	
61 (D.) Central Colorado.	4,324 square miles. 2,767,360 acres.	37 per cent. 1,600 square miles. 102,392 acres.	27 per cent. 1,167 square miles. 747,187 acres.	21 per cent. 908 square miles. 581,145 acres.	15 per cent. 648 square miles. 415,104 acres.	85 per cent. 3,676 square miles. 2,352,256 acres.	
62 (C.) Central Colorado.	4,324 square miles. 2,767,360 acres.	4 per cent. 173 square miles. 110,694 acres.	43 per cent. 1,859 square miles. 1,189,964 acres.	52 per cent. 2,249 square miles. 1,439,007 acres.	1 per cent. 43 square miles. 27,673 acres.	99 per cent. 4,281 square miles. 2,739,687 acres.	
61 (C 1.) Central Colorado.	1,098.3 square miles. 702,912 acres.	$\frac{1}{3}$ per cent. 5.49 square miles. 3,515 acres.	47 per cent. 516.2 square miles. 330,369 acres.	$9\frac{1}{2}$ per cent. 104.34 square miles. 66,779 acres.	43 per cent. 472.26 square miles. 302,249 acres.	57 per cent. 626 square miles. 1,400,663 acres.	
65. Eastern portion Eastern California and Southern Nevada.	Partial area 10,283 square miles. 6,581,120 acres.	2 per cent. 205.66 square miles. 131,622 acres.	6 per cent. 617 square miles. 394,867 acres.	88 per cent. 9,049 square miles. 3,991,360 acres.	4 per cent. 411 square miles. 263,244 acres.	96 per cent. 9,872 square miles. 317,876 acres.	
69 (A.) Southwestern Colorado and Northern New Mexico.	Total area 4,372 square miles; surveyed, 2,920 square miles. 2,798,208 acres.	15 per cent. 438 square miles. 280,320 acres.	44 per cent. 1,285 square miles. 722,272 acres.	41 per cent. 1,197 square miles. 766,108 acres.	Zero.	100 per cent.	
69 (B.) Southern Colorado and Northern New Mexico.	4,372 square miles. 2,798,208 acres.	5 per cent. 219 square miles. 139,904 acres.	60 per cent. 2,623 square miles. 1,678,848 acres.	99 per cent. 4,328 square miles. 2,770,227 acres.	1 per cent. 44 square miles. 279,810 acres.	99 per cent. 4,328 square miles. 2,770,227 acres.	Timber land is also grazing land.

69 (C.) Northwestern New Mexico.	4,419 square miles. 2,828,160 acres.	¼ of 1 per cent. 11 square miles. 7,040 acres.	25 per cent. 1,105 square miles. 707,040 acres.	75 per cent. 3,314 square miles. 2,121,120 acres.	Zero.	100 per cent.	
69 (D.) Central New Mexico.	4,419 square miles. 2,828,160 acres.	9 per cent. 398 square miles. 254,720 acres.	60 per cent. 2,651 square miles. 1,696,640 acres.	99 per cent. 4,375 square miles. 2,800,000 acres.	1 per cent. 44 square miles. 28,281 acres.	99 per cent. 4,375 square miles. 2,799,879 acres.	Timber land is also grazing land.
70 (A.) Northern New Mexico and Southern Colorado.	4,372 square miles. 2,798,208 acres.	9 per cent. 394 square miles. 251,827 acres.	62 per cent. 2,710 square miles. 1,734,809 acres.	99 per cent. 4,328 square miles. 2,770,227 acres.	1 per cent. 44 square miles. 27,981 acres.	99 per cent. 4,328 square miles. 2,770,227 acres.	Timber land is also grazing land.
70 (C.) Central New Mexico.	4,419 square miles. 2,828,160 acres.	4 per cent. 177 square miles. 113,125 acres.	30 per cent. 1,326 square miles. 848,640 acres.	66 per cent. 2,916 square miles. 1,866,585 acres.	Zero.	100 per cent.	
75. Central and Western Arizona.	17,954.6 square miles. 11,490,944 acres.	25 per cent. 4,488 square miles. 2,875,238 acres.	10 per cent. 1,795 square miles. 1,149,094 acres.	30 per cent. 5,386 square miles. 3,438,282 acres.	35 per cent. 6,284 square miles. 4,021,830 acres.	65 per cent. 11,670.6 square miles 7,469,114 acres.	
Totals.	100 per cent. 71,404.5 square miles. 45,698,880 acres.	11.5 per cent. 8,236.5 square miles. 5,271,360 acres.	31.7 per cent. 22,670 square miles. 14,508,800 acres.	55.7 per cent. 39,810 square miles. 25,478,400 acres.	13.5 per cent. 9,690 square miles. 6,201,600 acres.	86.5 per cent. 61,714 square miles. 39.497,280 acres.	Timber land in sheets 69*b*, 69*d*, and 70*a* is also grazing land.

52 D.—Almost the entire section is mountainous, the elevation being above 8,000 feet; it is too high for agricultural land.

The *principal valleys* are South Park, altitude from 9,500 to 10,000; Upper Arkansas Valley, 9,000 to 10,600; Blue River basin, 8,700 to 10,600; Ten-mile Creek and Blue River Valley, 7,800 to 11,000 feet.

The *timber* found up to timber-lines on all the mountains is spruce and pine; it is good for lumber. That along the streams is mainly cottonwood.

The *grazing* in the valleys is very good. It is usually necessary, however, to seek the lower lands for wintering cattle.

The land is mainly valuable for its *mines*. In the vicinity of Georgetown, Bakersville, and Gray's Peak, in northeastern part of sheet, silver-mines are worked. Silver-mines of Mount Lincoln and gold placer-mines near Granite Post-Office, and the Fairplay and Alma placers, are in the central part of sheet. In the western part of sheet are gold-mines on tributaries of Tennessee Creek. The water-supply, mainly of mountain-streams, is very good.

61 B.—Constituting a portion of Central Colorado. The greater portion of the sheet is mountainous, very little being under 7,000, in places running up to over 14,000 feet. The *principal valleys*, those in which the agricultural land is situated, are South Park, on the Platte, 8,500 to 8,800 feet; Upper Arkansas, 7,300 to 8,800 feet; Pleasant Valley, 7,000 feet; San Luis Valley, 7,700 to 8,500 feet; and Tumichi Valley, 7,500 to 8,000 feet. Crops are more or less uncertain, owing to the altitude.

In the northeastern portion of the sheet, and on the lower slopes of the mountains, throughout its whole extent, the *grazing* is good.

The *timber* in Saguache, Elk, and Sangre de Cristo ranges is pine and spruce, suitable for lumber. The scattered timber on foot-hills is mainly piñon, suitable only for fuel.

The *mines* at head of Chalk Creek, head of San Luis Valley, are silver and lead. Gold is found in place and placer-mines about Upper Arkansas, also in Union Park at head of Gunnison River; salt-wells at head of Salt Creek.

The *water*-supply is very good, from the South Platte, Arkansas, Gunnison, and San Luis Creek, with their many branches.

The *barren land* is above timber-line and along sides of cañons, where the bare rocks are developed.

61 D.—Half-mountainous. *Timber* on western rim of San Luis Valley. Piñons near valley on western foot-hills. Elsewhere spruce and pines. Large cottonwoods along Rio Grande, Alamosa, and La Jara Creeks. Sangre de Cristo range within limits of sheet, well wooded to timber-lines.

Agricultural lands on Rio Grande below mouth of South Fork, and in San Luis Valley along all running streams, also on Upper San Juan. Elsewhere land too high for cultivation.

Grazing lands.—San Luis Valley; hills of western boundary of San Luis Valley; on headwaters of the Cochetopa; on Upper San Juan. Large part of San Luis Valley covered with sage, but susceptible of irrigation.

Mines.—Summit and Decatur districts, on headwaters of Alamosa Creek, near divide between Rio Grande and San Juan waters. Gold and silver, principally the former. Gold found in Sangre de Cristo range; (not worked extensively.)

Barren land lies above timber-lines.

62 C.—The sheet lies in Central Colorado. In the western part the Sangre de Cristo, Greenhorn, and Culebra ranges limit the great plain extending eastward from their base. The *cultivatable land* is found in the valleys of the southern tributaries of the Arkansas, the Saint Charles, Greenhorn, Apache, Huerfano, Cucharas, Santa Clara, and Purgatoire; also along the Ute, Sangre de Cristo, and Trinchera Creeks. There is heavy pine and spruce *timber* on the mountains.

The *grazing land* in the mountain-valleys is very good, on the plains but indifferent, but not so poor as to be called barren. The little barren land of the sheet is above timber-line.

The *Rosita silver*-mining district is rapidly developing. Silver has also been found in Spanish Peak. Gold is found in the Sangre de Cristo range, iron on Grape Creek, and good coal in northwestern part of sheet.

The *water*-supply in the mountains is good, and on the plains sufficient for grazing lands, with enough for irrigation along the streams.

61 C, sub.—Central Colorado. Mountainous, except small tracts, perhaps 3 per cent. of level ground.

Timber.—Area well timbered with spruce upon the mountain-sides, and below 8,500 feet with large yellow pines and cottonwood. Scrub-oak, reaching 20 feet in height and 10 inches in diameter, found on Animas and Uncompahgre.

Agricultural lands are situated in the Uncompahgre Valley in north section of area, and on Lake Fork of the Gunnison. Good crops of wheat, corn, and vegetables may be produced in these small valleys.

Mines.—Extensive deposits and veins of gold, silver, lead, copper, manganese, and iron exist. Gold, silver, lead, and copper found in Upper Animas.

On headwaters of Uncompahgre, silver, lead, copper, and iron.
On headwaters of Lake Fork of the Gunnison, silver, lead, copper, no iron.
On headwaters of Dolores, galena-ores.
On headwaters of La Plata, gold veins, and below the mountains an extensive placer.
Limestone for flux is abundant; also in the Uncompahgre a fine flux in the shape of fluorspar is found.

Grazing lands.—Uncompahgre Park, Unaweep Valley in the north. The valley of the San Miguel to the west. The valleys and the rolling hills along the Animas on the south, and in the valley of the Rio Grande. Of these the San Miguel and Rio Grande Valleys are too high for winter grazing, reaching above 8,000 feet.

The *barren land* lies above timber-line, and along sides of cañons in inaccessible places.

65.—The sheet takes in a portion of Eastern California and Southern Nevada. That portion of the atlas sheet considered, lies east of the main range or Sierra Nevada. With their axis parallel to that of the main range, run the Grapevine and Funeral mountains; the Panamint and Telescope ranges; the Inyo, Cerro Gordo, Darwin, and Coso ranges. On all of these, excepting the northern portion of Panamint and Funeral mountains, and on the lower hills, piñon suitable for fuel only, is found. In the vicinity of Mazurka Cañon there is pine timber.

The *agricultural* districts lie mainly in Owens River Valley, with occasional minor tracts about springs and in Oasis Valley.

The *grazing* land extends off from the bases of the mountains limited by the lower valley land, such as Death Valley, Salinas and Butte Valleys.

Mines have been worked. Silver in the Panamint, Rose Spring, Lee, Cerro Gordo, Inyo mountain districts, and gold and silver in the Sherman, Lookout, and the district near Camp Independence. Silver and copper in the Ubahebe district, and gold in the old Coso and Owens Valley districts.

The *barren land* lies in the low valleys.

69 A.—This sheet covers a portion of Southwestern Colorado and Northwestern New Mexico. A little over one-half of the sheet has been surveyed.

The lands capable of *irrigation* lie along the San Juan River, and its branches coming from the north flowing from the San Juan Mountains, viz, the La Plata, Los Animas, Florida, Los Pinos, Piedra Blanca, and Navajo. The grazing land extending back from the valleys into the foot-hills; much of the grazing, particularly in the southern portion of the sheet, is very poor.

Timber found on the mesas and low hills is mainly piñon and cedar, of little value for lumber, but fine fuel.

Coal is found near Laguna Hedionda.

69 B.—This sheet covers a portion of Southern Colorado and Northern New Mexico, with the Rio Grande running through the eastern portion, *irrigable* land is found in the northeastern portion along the valley of this river; also the valleys of its tributaries, the Conejos, La Jara, the Culebra, Costilla, Colorado, Cristobal, and Montes, up the San Antonio and Los Pinos Creeks; in the western part on the Navajo, Blanca Chama and its branches, the Brazos, Nutritas, and Cangilon. Scant grazing found in the San Luis Valley; and very fine *grazing* in the spurs of the San Juan range and in the Rio Chama drainage-basin.

Fine pine timber and cottonwood found in the spurs of the San Juan.

Indications of silver in same; coal is found in southwestern part, near Laguna Hedionda.

69 C.—This sheet constitutes a portion of Northwestern New Mexico. It is very dry, almost entirely destitute of permanent water. In the eastern part the headwaters of the Puerco of the East give enough water for a little irrigable land, and at Ojo Nuestra Senora, in the center of the sheet, there is about a square mile of good land.

The country is not entirely barren, but the grazing is by no means good.

The timber is small, being piñon. Along the Chaco, water can be had by digging wells. Lignite is found along the Chaco and at the head of Cañon Blanco.

69 D.—In North Central New Mexico. The sheet is cut through by the Rio Grande, giving much irrigable land in its valley and those of its tributaries, Taos Creek, Embuda Creek, Cañada, Pojuaque, and Santa Fé on the east, Jemez and Chama, with its branches, Ojo Caliente, El Rito, Cañones, Cangilon, and Coyote on the west. Up from these, extending into the timber of the mountains, there is fine grazing.

On the Valles Mountains and Santa Fé and Vegas ranges fine spruce and pine timber is found. On the foot-hills there is piñon.

Indications of silver and gold are found in the Santa Fé and Las Vegas ranges, although there are no worked mines. Lignite is found on Santa Fé Creek. Copper is found in the Gallinas Mountains, also north of Abiquiu.

There is little barren land excepting that above timber-line.

70 A.—Sheet covers a portion of Northern New Mexico, and Southern Colorado. It is well *watered* by the Purgatoire, the Canadian, with its branches, Willow, Vermejo, Van Brummer, Ceroso, Ponil, Cimarron, Moreus, and Cineguilla Creeks on the east,

and the Culebra and Costilla on the west. In the valleys of all these, good irrigable land is found.

Grazing land extends over nearly the whole section, the grass being very fine.

Timber is pine and spruce in the mountains, and piñon and cedar on the low hills.

In Moreno and Ute Valleys place and placer gold-*mines* are found. Silver found on Colorado Creek in southwestern part of sheet. Gold and silver on Baldy Peak in Taos Mountains. Coal and iron found near Trinidad, and lignite croppings from Elizabethown to Trinidad in all cañons.

The little *barren land* lies above timber-line in the mountains.

70 C.—Situated in North Central New Mexico. The western third is mountainous. It is well *watered* by the Canadian and its branches, Cimarroncito, Rayado, Ocate, Sweetwater, and Mora, with its branches, the Sapello, Manuelitos, Cebolla, and Coyote, in the valleys of all of which is irrigable land capable of growing crops for three times the present population.

The *grazing* is wonderfully good, winter and summer, throughout the whole area excepting a little above timber-line.

Pine and spruce *timber* is found in main range and Turkey Mountains.

There are indications of *silver*, *gold*, and copper throughout the range, but no worked *mines*.

Sheet 75.—Parts of Central and Western Arizona. Much broken by low mountains and mesas with no well-defined ranges. There are no long watersheds to make large streams. The *water-supply* is not great. The Colorado Chiquito in the northeast runs through a cañon.

The *agricultural* land is found mainly about small springs in vicinity of San Francisco Mountains, in Chino and Williamson's Valley of the Rio Verde drainage, in vicinage of Camp Verde, about the heads of Bill Williams Fork, and on Hassayampa Creek and old Camp Date Creek and Skull Valley.

Pine and piñon *timber* is found on the mountains and piñon on the lower hills.

Grazing found in nearly all the valleys excepting in southwestern and northwestern part, where, as well as on the mountain-tops, it is arid.

Place and placer-*mines* of gold and deposits of silver are found in the Bradshaw Mountains.

BAROMETRIC HYPSOMETRY.

Lieutenant Marshall submits a report on this subject showing the operations carried on during the year, which have been principally with a view to the determination of altitudes alone, a large number of which have been fixed by both cistern and aneroid barometric measurements. A new set of instructions, enlarged, revised, and improved by Lieutenant Marshall during the year, have been published, and are sufficient for a complete manual that will answer for a long time to come. (See Appendix A.)

Dr. O. Loew presents a report on the meteorological condition of the Mohave Desert, and compares the results of his observations with those made in other countries.

The widely different climatic conditions existing in a comparatively limited area in Middle and Southern California make the observations of Dr. Loew of considerable value and interest. (See Appendix B.)

NATURAL HISTORY.

Geology.—Prof. Jules Marcou submits a report on the geology of a portion of Southern California; Dr. O. Loew, on the geolog cal and mineralogical character of Southern California and adjacent regions; and Mr. A. R. Conkling, on portions of New Mexico and Colorado.

The field was not an entirely new one to Professor Marcou, he having visited the region in connection with the surveys for a Pacific railroad along the thirty-fifth parallel; yet his report herewith will be found to contain new and valuable information. (See Appendix H 1.)

Dr. Loew was for most of the season attached to the party of Lieutenant Bergland, operating in connection with examinations to determine the feasibility of diverting the waters of the Colorado, and his notes on the geology and mineralogy of the region traversed, it is be-

lieved, will furnish information regarding the same heretofore but meagerly known. Attached to his report is a list of the rock and mineral specimens collected by himself and Mr. Conkling. He also submits a report on the chemical composition of the alkaline lakes, thermal and mineral springs of Southern California met with during the season. (See Appendixes H 2 and H 3.)

Mr. Conkling submits a report on the geology of the mountain ranges from La Veta Pass to the head of the Pecos River. (See Appendix H 4.)

Paleontology.—Collections in this branch were made by Prof. Jules Marcou and Messrs. A. R. Conkling and D. A. Joy, which have received a preliminary examination only. Whenever the necessary facilities will allow an analytical examination and report upon them will be made.

MINING IMFORMATION.

As in the preceding years, examinations into the general character, condition, &c., of mining districts and mines located within the areas entered by parties of the expedition have been made, and the following is a condensation from the results of the investigations for 1875–'76 of mines located in California, Nevada, Colorado, New Mexico, and Arizona.

BLIND SPRING DISTRICT, CALIFORNIA.

Examined by Dr. O. Loew, October, 1875.

The mines of this district are in the Blind Spring Mountains, an isolated range about eight miles long and three and a half wide, which lies between the Sierra Blanca and Sierra Nevada. The trend of its longer axis is north and south, following the direction of the mountains. Its croppings cover a large area, approximately 7,000 acres. Benton is the post-office. The nearest railway town is Carson, Nev., one hundred and sixty-five miles distant, with which it is connected by a freight and stage line. The roads in the neighborhood are through deep sand. This district was discovered in 1865, organized in the same year, and has been worked continuously since.

In 1871, a geological investigation was made by Dr. Hoffman of this survey. The direction of the lodes is north and south. The wall-rock is of granite. In the vicinity the azoic formation prevails. The main ores are argentiferous galena and argentiferous copper glance; but these are accompanied by other valuable minerals in large and small quantities, among which are partzite—a very rare silver ore, stetefeldtite, cerussite, malachite, cerargyrite, and chrysocolla. These metallic combinations are imbedded in masses in the ledge-matter, which consists of ferruginous clay and quartzites, and varies in width from 3 to 8 feet. Among the base ores, iron pyrites, cuprite, and zincblende in large and well-formed crystals occur. Indications of gold, varying from a trace up to $5 per ton, are found.

Some of the ores are treated by direct milling; others are previously roasted. Salt is added to the ores in roasting in order to convert the sulphates into chlorides; the escaping gases and fumes have a strong odor of sulphurous chloride.

The water-level has not yet been reached. The Comanche is the principal lode. It is a ledge of clay and quartzite from 3 to 8 feet wide, through which the ore is distributed. Its direction is north and south. The dip is 73°. It is between smooth granite walls, apparently

slickensided. It has a shaft 475 feet deep, with four levels. The vein of the Diana Mine dips 60° to the east. Its direction is north and south. It averages 5 feet in width, and contains free milling ore. The shaft is 590 feet deep, with five levels. The Eureka, Cornucopia, and Sierra Blanca lodes were worked extensively from 1865 to 1867, but since that time only at intervals.

There is a mill connected with the Diana Mine, and at the Comanche lode there are a mill and a furnace with two improved pans for amalgamation. All lead and copper found in this connection are lost, owing to the expense of transporting the apparatus and chemicals necessary to save them. The salt and soda used are obtained from Columbus, Nev., and Black Lake Flat, Cal.

A custom-mill will be erected soon. The cost of a 10 stamp mill will be about $25,000; with the stetefeldt furnace, $40,000. Freight from the railroad is 5 cents per pound. Other expenses will average as follows: Cost per ton for mining the ore, $15; for reducing, $20; mining labor per diem, $3.50; milling labor, $4; running a tunnel on main veins, per foot, $4 to $6; sinking a shaft, $6 to $18; running a drift, $4. One man can stope from one to three tons of ore per day.

The facilities for raising farm-produce are poor, as the soil is of coarse sand, and the water is insufficient for irrigation. Hay is worth $40 per ton; in the mountains there is some piñon and cedar timber. About 100 yards from the town of Benton there is a large hot spring, furnishing good palatable water and forming the source of a small creek. There are a few cattle in the vicinity, and some deer, rabbits, and quails. The inhabitants number about 600, besides two or three dozen Pah-Ute Indians.

HARDSCRABBLE DISTRICT, COLORADO.

Examined by Dr. O. Loew, August, 1874, *and A. R. Conkling, November,* 1875.

The Hardscrabble or Rosita district lies on the western slope of the Wet Mountains, near the edge of the park known as Wet Mountain Valley, and in the neighborhood of the town of Rosita, which is its post-office. Its nearest railroad-town is Cañon City, 29 miles distant, with which it is connected by freight and stage lines. Fare to Cañon City, $3; cost of freight, 1½ cents per pound. The country roads are good. The district was discovered and organized in 1872, since which time it has been worked at intervals.

A previous examination was made in 1873 by Prof. J. J. Stevenson of this survey. The district is very large, extending north to Grape Creek, and from the Wet Mountain Valley on the west to the plains on the east. It is in a region of rolling mountains of moderate elevation, whose general trend is north and south. The veins run northwest and southeast. Dip of main vein, 23° to the southwest. In a few cases they are natural fissure veins; generally, they are deposits which have been disturbed by volcanic forces. They are usually richer on the side of the hanging wall. The pay-streak is quite regular in form, and is seldom more than 6 or 8 inches thick. In the well-defined veins, the wall-rock is a porphyry; in other cases, quartzite. Barite in white tabular crystals occurs with the ore. In age the country-rock is azoic and paleozoic.

There are two classes of ore, for smelting and for milling, but principally of the latter class. Average yield about $80 per ton. A trace of gold has been frequently found in assaying. In the Virginia Mine, the yield of gold has been as high as 1 ounce per ton. The ores are argen-

tiferous galena, chloride of silver in clay and gypsum, copper glance, malachite, stephanite, stromeyerite, ruby silver, native silver in leaf-form, gray copper, chalcopyrite, and pyrite in cubes and pentagonal dodecahedrons. The base metals are lead and copper.

Water-level is reached at a depth of 30 feet, and marks a richer grade of ore. The examination of 1874 included 10 mines.

West Virginia, siliceous and clayey deposit, containing carbonates of copper, galena, chloride of silver, and manganese.

Humboldt, same character of ore; dip of strata, 75° south-southwest.

Pocahontas, same character of ore, with gypsum-spar, iron, and copper pyrites, galena, carbonate of lead, and chloride of silver.

Del Norte, crevice, 2 feet in width.

Leviathan, crevice, 11 feet.

Chieftain, crevice, 3½ feet.

Pioneer, shaft, 70 feet.

Minnesota, gypsum-spar and clay, with chloride of silver, pyrites of iron, and galena; assay, $60.

Pelican, crevice, 8 feet; assay, $60; dip, 72°.

Senator, strike, east and west; dip, 44°; vein, 3 to 8 feet wide; wall-rock, porphyritic trachyte; ore, principally galena in quartzite; assay, from $25 to $1,200 per ton; resembles a true fissure-vein.

In 1875, the assay of the Pocahontas was reported to be 220 ounces; of the Virginia, 228 ounces. Between March and November, 1875, $50,000 were expended on the Pocahontas, and $120,000 extracted. The reduction-works began operations in July, 1875. There is one mill with a Dodge crusher and four or five pans; capacity, four tons per day. The amalgam is strained cold.

The cost of a 10-stamp mill would be $30,000. Other expenses will average as follows: Mining the ore per ton, $10; reducing, $40; mining labor per diem, $3; milling labor, $3; running a tunnel on main vein per foot, $8; sinking a shaft, $7.50; running a drift, $3.50.

There are poor facilities for farming, but in the Wet Mountain Valley, seven miles distant, there is good grazing country, supporting 25,000 cattle. Hay is worth $20 per ton; grain, 4 cents per pound. There is an abundance of wood and water, and coal within twenty miles. The inhabitants number about 1,000. Plenty of game is found, including the deer, bear, mountain-sheep, grouse, turkey, prairie-chicken, duck, fox, beaver, mink, wolf, and badger.

PANAMINT DISTRICT, CALIFORNIA.

Examined by Dr. O. Loew, October, 1875.

This district is situated in the Panamint range of mountains, between Death Valley and Panamint Valley. Its croppings cover an area of about 6 square miles. The ledges traverse the main range, occurring chiefly on the western slope, upon which there are but few spurs and foot-hills. The post-office of the district is Panamint. It is connected with the railway at Caliente by a stage-road via Shepperd's Cañon and Indian Wells. The distance is 160 miles; fare, about $40. The cost of freight from San Francisco, via Caliente, from which point wagons run, is 5 cents per pound. The completion of the Independence Railroad will reduce the cost of transportation. The roads to the mines, upon the mountain-slopes, are very good, but the routes to Caliente and Darwin lead through deep sand.

The lodes are confined to the higher portions of the range. Their di-

rection is north-northeast and south-southwest. The ore occurs in masses of different sizes, imbedded in the quartz ledge, whose position is nearly vertical between walls of crystalline limestone and calcareous conglomerate. The veins are well defined and large, and the walls are generally slickensided. The mass of the mountain range is granite. In many places in this there are dikes of intrusive rock, such as diorite, porphyry, and serpentine. In the vicinity of the mines, especially, the granite is accompanied by talcose schist, primitive limestone, primitive clay slate, hydraulic limestone, and calcareous conglomerate. No fossil shells are found in the higher portions of the range. In the lower portions occur more recent formations, such as the quaternary, which covers the Panamint Valley. In this valley there are also hot springs, and saline deposits from which salt is obtained for the roasting purposes of the mines.

The products of these mines are partly free milling-ores and partly roasting-ores; the latter are milled after the completion of the roasting process. Their average yield per ton is from $90 to $120. No gold is found. The silver ores are principally chloride of silver, stromeyerite, stetefeldtite, and argentiferous copper glance, with native silver, and, rarely, argentiferous galena. Copper is the chief base metal. A little antimony accompanies the ore, and, exceptionally, some iron pyrites and zinc-blende.

The principal mine of this district is the Hemlock, whose ledge has been traced for 1¼ miles, appearing on the other side of the hill as the Alabama lode. The ledge dips 80° to the southeast, and varies in width from 1 to 6 feet. Though in some places barren, it is again very rich. It has been pierced by two tunnels, 75 feet and 229 feet in length, from which drifts and winzes have been pushed. Next in importance is the Wyoming lode. This ledge, running through limestone, varies in width from 2½ to 10 feet, with a branch vein from 2 to 6 feet wide, diverging from the main lode at an angle of 15°. Two drifts, 240 feet and 500 feet in length, and two tunnels, 160 feet and 180 feet long, have been run. The Surprise lode is large and well defined, 6 feet in width, and is apparently a continuation of the Wyoming. The World's Wonder and Stewart's Wonder are worthy of mention, and, in addition to these, there are a dozen others, equally as good, which are not worked at present. No positive data can be given concerning the expenditures and receipts of this district, but the product of the furnace for one month was 40,000 ounces of silver.

The Sunrise Company runs a 5-stamp mill, but, having no roasting furnace, works only free milling ore. The Surprise Valley Company has a stetefeldt furnace and a 20-stamp mill. Each stamp weighs 900 pounds, and makes 85 drops per minute. There are two crushers, working 25 tons of ore per day. There are ten amalgamating pans, each holding a ton of roasted ore. The amalgam is strained cold. It is generally composed of 1 part silver to 5 part mercury, with a little lead and copper. The furnace is constructed for working 40 tons of ore per day. It is discharged every 1½ to 2 hours. From 3 per cent. to 10 per cent. of salt is added to the crushed ore in roasting.

The cost of machinery is unusually high, owing to expensive transportation. The stetefeldt furnace cost $18,000. Other items of expense will average as follows: Mining labor per diem, $4; milling labor, $5.50; running a tunnel on main vein, $10 to $15. The present sources of grain supply are Los Angeles and Caliente. Hay is brought from the northern portion of Inyo County. With an influx of settlers these commodities may become cheaper, as there is some good farming-land

in that region. The timber is chiefly of piñon and juniper; its quantity is small, but sufficient. The water is very good and pure, and there is enough in the vicinity to run another 30-stamp mill. The Surprise Valley Company owns a large spring near the mines, and the Sunrise Company has a well 40 feet in depth. There are about 500 inhabitants in the district, besides some Pah-Ute Indians.

CHARLOTTE DISTRICT, CALIFORNIA.

Examined by Lieut. C. W. Whipple, July 20, 1875.

This district is at the head of the Tejongo Creek, near the summit of the San Gabriel Mountains. It is about 40 miles from Los Angeles, its principal source of supply, and 32 miles from San Fernando, which is the most convenient post-office and railway-station. It is now reached by a difficult trail up the Tejongo, over which supplies are transported on burros. An easier trail, by way of the Arroyo Seco, is believed to be practicable and will be attempted.

It was discovered in 1870 by Mexican herders. Since that time it has been worked at intervals by these people and by the proprietors of the Harding Mine. No geological examination has been made, but the main vein has been followed a distance of 4 miles in a southeast direction. The rock of the walls and in the vicinity is almost entirely quartz, but farther down the stream it is a coarse, friable granite. No silver has yet been found. The vein is of gold-bearing quartz, in which some iron pyrites occur. In places this is hard and compact, and again it is soft and earthy.

The mountain range has here a general east and west trend, with spurs projecting to the south, which are traversed by the several veins. The Charlotte and Las Animas Mines are upon the same vein. The former,* upon which work is now in progress, has been sunk to a depth of 11 feet. The main vein is about 3 feet wide, and is crossed diagonally by another, 18 inches in width, with an inclination of 30°. The Poyorena, the Union, and Mejicana are on a second vein. Work upon the Poyorena is about to be resumed. Its shaft has reached a depth of 30 feet. The vein is 3 feet thick, extending without fault from surface to bottom. The Union is at a depth of 40 feet. The Pacific, on a third vein, was not visited. The Harding Mine has reached a depth of 40 feet.

The quality of ore seems to improve with increase of depth. In places it is very rich, the managers of the Charlotte Mining Company claiming that these culled pieces will assay $300 per ton. This company has completed two arrastras, with which they expect to work two tons of ore per day. It is anticipated that it will cost $30 per ton to extract and work the ore.

The district is peopled by about fifty miners and prospectors. The supply of water in summer is scanty, proceeding from the springs at the heads of the valleys. On the north exposure of the mountains, near their summit, there is good pine timber. Bear and deer are plenty.

The principal impediment to the development of this district is its inconvenience of access. With a new road, which would allow the introduction of improved machinery, it might be very profitably worked.

SAN EMIDIO DISTRICT, CALIFORNIA.

Examined by Douglas A. Joy, November 9, 1875.

This district is in the San Emidio Mountains, at the head of Plato Creek, on the divide between this stream and the San Emigdio Cañon.

* This mine has since been abandoned.—Ed.

It was discovered in 1871, since which time it has been continuously prospected. It is connected by trail with the San Emigdio Cañon, and thence by wagon-road with Bakersfield, 45 miles distant, which is the most convenient post-office and railway station.

The outcroppings follow the top of the ridge, which has a general east and west trend. They have been traced more than 3 miles, but the exact area of the district is uncertain. The strike of the vein is due north, and its dip, according to the best estimate, is 90°, vertical. The country-rock is massive granite. The dependence of the quality of the vein upon the local character of the country-rock has not been investigated.

The wall-rock is granite. Its dip is 90°. Tertiary sandstones overlie this rock about 4 miles down the ridge. The character of the vein has not yet been determined. None of the ore extracted up to date has been worked. It is proposed to smelt it in a reverberatory furnace to crude antimony, (pan sulphuret.) The ore extracted assays 75 per cent. of sulphuret.

The ore is nearly pure sulphuret of antimony, with some silver and iron. Some quartz is irregularly intermixed, and also a little feldspar. The greater part of the ore is colored red on the outside by oxide of iron, and, until broken, does not show the characteristic black metallic appearance. It is hard, and but little decomposed.

The district has been worked in but one place, and not extensively there. The water-level is not yet reached. Several tunnels, from 15 to 45 feet in length, have been run, but nothing more has been done. This mine is supposed to have been worked in former times by the Spaniards, as there are indications of previous labors here, and in the adjacent valley of Plato Creek an old furnace has been recently discovered.

The vein-matter should be followed in running shafts and drifts. On an average, eight tons of ore can be stoped per diem by one man. Water is abundant in the neighboring cañons. The country roads are good. On the surrounding mountain slopes there is good pasturage and excellent pine timber. Deer, grouse, and mountain-sheep abound in the mountains, and antelope on the plains.

GREEN MOUNTAIN DISTRICT, CALIFORNIA.

Examined by Douglas A. Joy, October 6, 1875.

The Bright Star Mine is the principal one in this district. It is situated at an elevation of about 8,000 feet, within a mile of the summit of the Pah-Ute Mountains, which lie in a clump between the Kern River and Kelso Valley, about 15 miles south of Kernville. The district was discovered in April, 1866, by a Mr. Rains. It was organized in the same year, and has been worked continuously since that time. Its most convenient post-office is Havilah, with which it is connected by trail. The nearest railway station is Caliente, which, by wagon-road, is 85 miles distant. The country roads are good, though steep. Cost of freight from Caliente is 3½ cents per pound.

The exact area of this district is not known, as no geological surveys have been made. The superintendent of the Bright Star Mine claims to have traced the vein-wall a distance of 1½ miles, but admits that the substance of the vein is not entirely quartz. Its general trend is northeast and southwest. There is no other mining ledge in the immediate vicinity.

The walls are slickensided, and there are other indications of a true fissure-vein. It dips at an angle of 82°. Its strike is northeast, directly perpendicular to the bedding of the country-rock. The rock is primitive, granite and syenite. The mineral constituents are very irregularly scattered. Sometimes they are almost purely quartz and feldspar, and again are chiefly hornblende, or mica schist.

The native metals alone are collected. This is done by amalgamation in stamps. The average yield per ton is about $22. The bullion obtained is an alloy of gold and silver, one part silver to two parts gold, whose average worth is $14 per troy ounce. Water leaks in at various levels, especially at the lowest, which is 280 feet below the surface. No change has been observed in the character of the ore, which is a compact quartz, containing native gold and silver, with which are mixed sulphurets of arsenic and antimony, and pyrites in small quantities. As it comes from the mine, the ore is mixed with clay and country-rock from the horses and walls. The vein-rock is but little decomposed. The native metal can occasionally be distinguished with the naked eye. The sulphurets occur both in specks and in masses of considerable size.

About $150,000 has been expended on the Bright Star Mine, from which 1,200 pounds troy of bullion, valued at $14 per ounce, have been taken. Its ores are worked by one mill, with three batteries of five stamps each, which make 85 drops per minute. The entire mill is run by one small engine of 35-horse power. There is a great scarcity of water, the only source of supply, aside from two or three small springs, being the mine itself, which furnishes enough for the engine, the stamps, and culinary purposes. The sulphurets have not been treated yet, but are allowed to accumulate and await the completion of a furnace in which they may be roasted.

The cost of a 10-stamp mill on the grounds is about $6,000. Other expenses will average as follows: Cost per ton for mining ore, $2; for reducing the same, $2; mining labor, per diem, $3.37; milling labor, $4; running a tunnel on main vein, per foot, $6; sinking a shaft, $12; running a drift, $6. One man will stope two tons of ore per day.

There is but little farming-land in the immediate vicinity, and but few cattle or other stock. The present sources of supply are Kernville, Havilah, Kelso Valley, and small valleys in the mountains. Grain is worth 5 cents per pound; hay, $25 per ton. The mine is surrounded by very heavy pine timber. Deer and quail abound.

CLARKE DISTRICT, CALIFORNIA.

Examined by Dr. O. Loew, July, 1875.

The Clarke Mountain, near Ivanpah, is a part of the Opal Mountains. On both sides of this, but especially on the eastern slope, are the mines of the Clarke district, whose croppings cover an area of great extent. This district was discovered in 1869, was organized in 1870, and has been constantly worked since. Its post-office is Ivanpah. The nearest railway town is San Bernardino, which is 200 miles distant, via Soda Lake and the Mohave River. Cost of freight from this point is 5 cents per pound.

The mines were previously examined by Lieutenant Wheeler in 1871. The direction of the lodes is east and west, transverse to the general trend of the district. Quartzite and paleozoic limestone form the wall-rock; the vein-matter is quartz, and, in some instances, calcspar. In

age the country rock is paleozoric and azoic. Syenite, granite, porphyry, mica schist, slate, sandstone, and limestone are present.

Some of the ores are free milling; others require roasting. In the quartzite, the principal silver ores are argentiferous galena, stromeyerite, stetefeldtite, and pyrargyrite; in the limestone, they are massicot, minium, cerussite, malachite, and cerargyrite, or chloride of silver. Gold is present in the argentiferous quartz.

The water-level has not been reached. The most important mines are the Beatus, with a shaft 300 feet, and 3 levels 100 feet each; the Snow Storm, rich in carbonate of lead, with a shaft 80 feet deep; the Lisa Bullock, whose ore is chiefly stromeyerite, assaying $600 per ton, whose shaft is 100 feet deep, with two levels, and whose vein is 4 feet wide, with walls slickensided; the Lucky Boy, with shaft 61 feet deep and vein 5 or 6 feet wide, whose principal yield is galenite, assaying from $20 to $50 per ton; the Stonewall, with shaft 50 feet deep; and the Savage, whose shaft is 40 feet deep, and whose vein, which has been traced for 1,000 feet, is 5 feet in width. The ore of the latter is chiefly carbonate of lead and minium, assaying from $30 to $40 per ton. The Green-Eyed Monster and Copper World are also good mines. About 12 miles south of Ivanpah, but still in Clarke district, is the Bullion Mine, containing malachite, minium, and chloride of silver. There are one small mill of ordinary construction and one smelting-furnace attached to these mines. The yield has been about $300,000.

The cost of a 10-stamp mill, including transportation, would be $25,000. Other expenses will average as follows: cost of mining the ore per ton, $20; reducing, $25; mining labor, per diem, $4; milling labor, $3; running a tunnel on main vein, $5 to $6; sinking a shaft, $10. One can extract 500 pounds of ore per diem.

The supply of water is limited, and there are but few facilities for farming. Some piñon and juniper grow on the mountains, and pine timber is found 75 miles north of Ivanpah. Mountain-sheep are the only game. There are a few hundred domestic animals in the vicinity. The country roads are tolerable. The inhabitants number about 100, besides 40 or 50 Pah-Ute Indians.

WASHOE DISTRICT, NEVADA.

Examined by Dr. O. Loew, October, 1875.

The Washoe district, celebrated for its Comstock lode, is on the eastern slope of the Virginia range, and in the immediate vicinity of Virginia City, which is its post-office. It is connected by rail with Reno, on the Central Pacific Railroad.

Thorough geological examinations have been previously made by different parties, especially by James D. Hague, of Clarence King's survey, in vol. III of the reports on which this district is treated at length. The ore of the Comstock lode occurs in pockets, and as impregnation in very wide quartz ledges, which traverse the country-rock in a northeast direction. Not infrequently the quartzitic vein matter is accompanied by clay and calcite. The country-rock is principally azoic; syenite is its largest constituent, but feldspathic porphyry is also frequent. In some instances the latter shows an advanced degree of decomposition, the feldspar being converted into clay, even while retaining the original crystalline form.

In nature the ores are chiefly free milling, although undoubtedly some of them would be benefited by previous roasting. The average assay

yield is from $50 to $60. Water-level has been reached in all shafts. In the Ingersoll Mine hot water has been encountered.

The principal ores are chloride of silver, or cerargyrite, brittle silver, or stephanite, pyrargyrite, polybasite, free gold, native silver, argentiferous galena, copper glance, zinc blende, and iron and copper pyrites. Antimony, copper, and lead are the chief base ores. Gold occurs in all of the silver ores, and forms an important share of their values.

Only two mines, the Belcher and the Imperial Empire, were visited. The shaft of the Belcher is 850 feet deep vertical, then 750 feet inclined. Work is being prosecuted on the 1,600-foot level. Four hundred tons per day are extracted. This amount is the working capacity of the mills at the time of high water in the Carson River. At other seasons not more than 150 or 200 tons can be reduced, and less ore is then extracted. Since 1860 166,000 tons have been taken from this mine. The ledge varies in width from 25 to 50 feet. Its strike is northeast and southwest. The ore is found in pay-streaks, and also occurs as impregnation.

In the Imperial Empire the vein is 25 feet wide; the strike northeast and southwest; the shaft 2,000 feet deep; the average yield, 40 tons per day of good milling ore.

Since work began on the Belcher, in 1860, silver and gold bullion to the value of $28,000,000 has been extracted, and dividends have been paid to the amount of $15,000,000. The yield for 1874 was $9,150,000; in 1875 it was $200,000 per month. In 1870 the total product of all mines in the vicinity did not reach that amount.

California is the chief source of supply for produce, &c. The nearest timber of importance is in the mountains near Cañon City. Some water is found in the mines, but the whole supply for Virginia City is not great.

HUALAPAIS DISTRICT, ARIZONA.

Examined by Dr. O. Loew, August, 1875.

The mines of this district are in the Cerbat range of Arizona, principally on the western slope. The trend of the mountains is northwest and southeast; of the district and of the veins, nearly the same. The croppings cover a belt 10 miles long and 2 miles wide, lying between Sacramento Valley and Hualapais Valley. Mineral Park is the district post-office. The stage-line from Prescott to Hardyville passes here. Cost of freight overland from California is 8 cents per pound; by vessel via Yuma to Hardyville, and thence by wagon 30 miles to Mineral Park, it is 5 cents per pound. The roads are very good. This district, formerly called Sacramento district, was discovered and organized in 1863, but, in consequence of Indian troubles, has been worked but desultorily.

These mines were examined by Lieutenant Wheeler in 1871. The veins are well defined. Their angle of dip is from 70° to 80°. They appear to be richer where the country-rock is more micaceous. Some are contact veins, between syenite foot-wall and porphyry hanging-wall. The vein matter is chiefly quartz. The rock is azoic. Its principal constituents are granulite, granite, apatite, talcose schist, syenite, and quartzite, tinged with iron and manganese. Dikes of intrusive porphyry rock are occasionally met.

There is but little free-milling ore; it is chiefly roasting. Assays show a yield of $60 to $1,400 in silver per ton. Some gold occurs with the silver, and in some mines the gold predominates in value. The ores are galenite, pyrargyrite, or ruby silver, cerargyrite, or chloride of

silver, chrysocolla, pyrite, cerussite, chalcocite, and sphalerite, or zinc blende. Base metals are copper, lead, antimony, iron, and zinc.

The Keystone lode is from 2 to 5 feet wide, with seams of ruby silver and separate seams of base sulphurets, which in this ore never mix with the high sulphurets. The ledge is of great extent, with seven located claims. Its shaft is 185 feet deep, with 2 levels, 40 feet long. The Lone Star has a shaft 200 feet deep, with 2 levels. Gold abounds in its ore. The main quartz ledge of the Metallic Accident is from 12 to 20 feet wide; shaft 60 feet deep. The main vein is composed of 2 parallel ledges, which are cut by a third at right angles nearly. Its ore is chiefly chloride of silver, assaying on an average $800 per ton. The Sixty-Three lode has 3 tunnels, averaging 250 feet in length, with shafts 200 feet deep. The Montezuma contains chrysocolla and chloride of silver. The Cerbat lode assays $150 per ton. Of this two-thirds is gold. Much ore has also been taken from the Cupel and Little Tiger mines.

About $60,000 worth of bullion has been taken from the Sixty-Three lode; expenditures nearly the same. Further estimates are not reliable. There is one 5-stamp mill, and a second in course of construction. Each stamp weighs 850 pounds, and makes 90 drops per minute. There are 2 furnaces and 2 5-foot combinationa pans. If much lead is present, the amalgam is strained hot; otherwise, cold.

A 10-stamp mill, with 2 furnaces, will cost, including transportation, $45,000. Other expenses will average as follows: Cost of reducing the ore, per ton, $50; running labor, per diem, $4; milling labor, $4.50; mining the ore, per ton, $12; running a tunnel on main vein, $15; sinking a shaft, $25; running a drift, $12.

No farming is done. There is some good grazing country, but not much stock. Grain is brought from California. Its cost is 8 to 10 cents per pound; cost of hay, $20 per ton. Timber is scarce. The water at the mines contains sulphate of lime and magnesia; but pure water is obtained from the mountains, 4 miles away. The mountain-sheep, antelope, deer, quail, and rabbit are found. The Hualapais Indians live in the vicinity. About 100 whites people the district.

NEW COSO DISTRICT, CALIFORNIA.

Examined by Lieut. Rogers Birnie, jr., and Dr. O. Loew, 1875.

This district is in the main ridge of the Coso range, on both slopes of the same, in the vicinity of the town of Darwin, which is post-office to the district. It is of great area, lying between Panamint Valley on the east and Owen's Lake on the west. It is connected by stage with Caliente, 120 miles distant; fare, $30. Cost of freight from the same point, by the Cerro Gordo Freighting Company, is 5 cents per pound. The district was discovered and organized in 1874.

The dip of the veins is 60°. The wall-rock is principally limestone, in addition to which granite and basalt are found. A ledge of limestone, varying from 200 feet to an indefinite width, runs northwest and southeast, which is also the general trend of the mountains and of the veins. The country-rock is chiefly azoic. Dikes of basalt and hornblende porphyry occur in the limestone. No fossil remains are found.

All ores are treated by the smelting process, which, however, is not entirely satisfactory, as much silver of the chloride is volatilized and lost. Assays yield from $30 to $600 per ton. Gold is found in considerable quantities, from $5 to $140 per ton of ore. The yield of silver is

from 40 to 50 ounces per ton. Iron forms 4 per cent. of the ore, and lead from 40 to 65 per cent. of the same. Saltpeter is found in the southern portion of the district.

Silver is present as sulphide in the galenite, and as chloride in the cerussite and massicot; these ores are intermixed. Mingled with these in small quantities are blue and green carbonates of copper, (azurite and malachite,) silicate of copper, (crysocolla,) black and red oxides of copper, (melaconite and cuprite,) oxides of iron and manganese, and iron pyrites. The fissures in the limestone are filled with solid chunks of galena, imbedded in a pulverulent mass composed of yellow and red oxides of lead and carbonate of lead. Here and there calc spar and seams of reddish argillaceous limestone occur in the vein matter, and also occasional bowlders of limestone. The walls are frequently slickensided, and in some instances show "breaks," or hollow fissures, probably caused by earthquakes.

The Defiance lode is situated one-half mile east of Darwin, in a belt of limestone about 500 feet wide, which is bordered on the east by granite and a dike of hornblende porphyry, and on the west by slate. The lode consists of four broad, parallel veins, of 45, 27, 47, and 28 feet in width. Dip, 40° to southwest; course, northwest and southeast. The average assay yield is $50. Expenditures, $4,000; receipts, $5,000. One tunnel is in course of construction.

The vein of the Bella Union is from 5 to 8 feet wide. It has a feeder uniting with it at a very acute angle. The walls are slickensided, especially the foot-walls, and a series of lines like scratches, with a dip of 25°, are seen on them. The ore assays from $60 to $75. Over 100 tons have been extracted from the feeder, and 400 from the main vein. Expenditures, $4,000. No bullion has yet been obtained. The Lucky Jim and Christmas Gift are two other large mines, worked at present.

There is one smelting-furnace in operation and another in process of construction. The furnace of the Defiance Company will cost $20,000. It will be an iron furnace, of 50 tons capacity. The boiler will be of 42-inch diameter and 16 feet in length. Other expenses will average as follows: Cost of mining the ore, per ton, $2; smelting, $10; mining labor, per diem, $4; milling labor, $4; for cross-cutting a tunnel, per foot, $20; cross-cutting a drift, $20; sinking a shaft, $12. One man can stope or extract 5 tons of ore per day.

There are no facilities for farming, as there is not enough water for irrigation. Hay and grain come from Owen's Valley. Hay costs $60 per ton; grain, 6 cents per pound. Some piñon timber grows 8 miles from Darwin. Water is very scarce and is sold for 2½ cents per gallon in Darwin, whither it is brought in pipes from the mountains several miles distant. There are about 1,000 cattle and 200 horses in the district, which affords poor grazing. Rabbits, quails, and deer are the kinds of game. About 500 people live here.

BANNER DISTRICT, CALIFORNIA.

Examined by Geo. H. Birnie, April 19, 1876.

This district is in the central part of San Diego County, in a cañon of the Quiamaca Mountains, and on the foot-hills on both the east and west slopes of the same. It covers about 36 square miles. The trend of its longer axis is north 8° west. The course of the mountains is north 10° west. The Banner district was discovered in 1870 by Louis B. Redman. It was organized in the same year, and has been worked continuously since.

Its post-office is Banner. The nearest railway is at Seven Palms, in the Coahuila Valley, but there is as yet no practicable route thither. The railway station most convenient of access is Anaheim, distant 116 miles. The district is connected by stage-line with San Diego; fare, $5. The cost of freight from San Diego is 1¾ cents per pound. The local roads are tolerable.

A geological investigation has previously been made by Mr. Buoy, of San Francisco. The lode dips to the east at an angle of 65°. Its direction is north 10° west. The wall-rock is of slate and granite; the vein is richer in the slate. No fossils have been discovered in the vicinity. A little galena has been found. The ore is a laminated quartz, containing some arsenic and antimony. It is worked by the wet process, yielding from $20 to $50 per ton, principally gold, but with an alloy of 4 per cent. of silver. The water-level has been reached, but it marks no change in the nature of the ore.

The principal mines now worked are the Ready Relief, Hubbard, and Kentuck. The Golden Chariot, which has reached the greatest depth, is now suspended, with the intention of resuming operations soon. They are all on the mountain-side, with shafts on an incline of about 65°. Up to date the Golden Chariot has expended, approximately, $200,000 and extracted $300,000, and the Ready Relief has expended $100,000 and extracted $150,000. The mill of the Ready Relief has 10 stamps, with settling-pans. The Golden Chariot mill is similar. The Whitney mill has 10 stamps. There are no crushers. Each stamp, weighing 750 pounds, makes 80 drops per minute. Each mill has three settlers. Cold amalgam is used.

The cost of a 10-stamp mill without roasting-furnace, including transportation and erection, is about $12,000; other expenses will average about as follows: Cost per ton for mining the ore, $10; for reducing the same, $2; mining labor, per diem, $3; milling labor, $3; running a tunnel on main vein, $16; sinking a shaft, $25. One man can stope or extract one-half of a ton of ore per day.

In the vicinity there are some stock, chiefly cows, sheep, and horses. Barley is valued at 3 cents per pound; hay, at $40 per ton. San Diego is the principal source of supply. There is a plenty of water and of oak and spruce-pine timber. Black-tailed deer, quails, rabbits, hares, and pigeons abound. The district numbers about 75 inhabitants, besides a body of 100 Diegueños Indians.

NEW ELDORADO DISTRICT, CALIFORNIA.

Examined by Douglas A. Joy, October 8, 1875.

The ledges of this district lie in a range of hills between Kelso Valley and the Mohave Desert. Its principal opening, the St. John's Mine, is on the divide between Kelso Valley and Kelso Cañon, east of Pah-Ute Mountain. It was discovered by Mr. St. John in 1866, organized the same year, and worked continuously since that time. Caliente, the nearest railway station, is distant 75 miles by wagon-road.

No regular geological examination has been made, but the district has been traced by croppings 2½ miles, and may extend farther. The general direction of the vein is northwest and southeast. The general dip in the main shaft is 37°. Both foot and hanging walls are of massive granite, with no decided bedding. The direction of their slope is very irregular, but, in general, is 37° northeast and southwest. Though

slickensided and possessing other features of a true fissure vein, it is undoubtedly not such.

The material of the country-rock is granite. The mineral constituents are very irregularly distributed, both mica and feldspar often disappearing, leaving quartz and mica or quartz and feldspar only. The mica is often replaced by hornblende, forming a syenite, and again the rock seems to be composed entirely of hornblende.

At the water-level, 300 feet down, the ore is greatly decomposed, requiring only a pick and shovel to extract it. But at the lowest level, 700 feet, the quartz is very hard and at its richest quality. The ores are worked by the wet milling process. The supposed average yield is $30 per ton. Some ores, found in small quantities, have assayed as high as $60 per ton.

The ore contains about half as much silver as gold. The gold generally occurs in native condition. At the lowest level it is found in leaf state, and is readily seen with the naked eye. Some yellow sulphurets of iron and black sulphurets of arsenic and antimony are found, but these are not sufficient in quantity to be profitably utilized.

The St. John Mine has been worked nearly ten years, in which time, by estimate, $80,000 has been expended and bullion to the amount of $200,000 has been extracted. It possesses a 12-stamp mill, each stamp weighing 750 pounds, and making 82 drops per minute. The amalgam is strained cold, through canvas bags, no pan amalgamation being carried on.

The cost of a 10-stamp mill, including transportation from San Francisco and erection on the grounds, is about $4,500. Other expenses average as follows: Cost per ton of mining the ore, $4; reducing the same, $4; mining labor per diem, $2 and board; milling labor, $3 and board; running a tunnel on main vein, per foot, $8; sinking a shaft, $16; running a drift, $8. One man will stope or extract two tons of ore per diem.

The neighboring country roads are good, but steep. The water used is obtained entirely from the mine, there being no large stream nearer than Kern River. Kelso Valley is well adapted for farming and grazing purposes, and upon this plain and in its vicinity there are, perhaps, 10,000 cattle. On the summit of Pah-Ute Mountain, about five miles distant, there is an unlimited quantity of heavy pine timber. The principal kinds of game are deer, grouse, and bear.

JULIAN DISTRICT, CALIFORNIA.

Examined by George H. Birnie, April 19, 1876.

The Julian district is near the center of San Diego County, on the headwaters of San Dieguito River. It is 122 miles from Anaheim, by the old Government road from Wilmington to Fort Yuma. The Southern Pacific Railroad at Seven Palms, in the Coahuila Valley, is nearer, but there is no practicable road to it. There is a mail stage tri-weekly to San Diego; distance, 65 miles; fare, $5. The post-office is Julian. The mountain-roads in the vicinity are very good.

The first discovery in this district was made in 1870, by Messrs. Julian and Bailey. It was organized in the same year, since which time it has been worked continuously. The district is 6 miles long and 2 miles wide, following the summit-line of the Quiamaca Mountains, which have a north-northeast trend. The direction of the lodes is north-northeast. The dip is 45; the wall-rock is of granite and slate; the veins

are found to be richer in slate. Water has been reached at a depth of 260 feet, at which level the ledges are better defined and of a superior quality. At a depth of 400 feet the veins continue good.

The average yield per ton is $20; of this amount one per cent. is silver, and the remainder is gold. The ore is worked by the wet process. It is a laminated quartz, nearly pure. Sulphurets of iron and arsenic are found in small quantities, but nothing more.

The principal mines are the Helvetia, Tom Scott, Pride of the West, and Washington; all on the summit of the mountain-range. Of these, by approximation, the Helvetia has expended $40,000 and extracted $55,000; the Tom Scott has expended $10,000 and extracted $20,000; the Washington has expended $10,000 and extracted $20,000; and the Pride of the West has expended $5,000 and extracted $10,000. There are two mills running. The Helvetia has 10 stamps, weighing 650 pounds each, and making 90 drops per minute. It has no crushers and no settlers; cold amalgam is used. The engine is of 15 horse-power. The Reynold's (custom) mill has but 5 stamps; in other respects it is similar to the Helvetia.

A 10-stamp mill will cost, on the grounds, about $12,000. Other expenses will average as follows: Cost of mining the ore per ton, $6; reducing the same, $2; mining-labor per diem, $3; milling labor per diem, $3; running a tunnel on main vein per foot, $10; sinking a shaft, $25; running a drift, $9.

The surrounding country is excellently adapted for farming and grazing, and great numbers of stock are raised. All necessary produce is grown in the district. Barley is worth 2½ cents per pound; hay, $15 per ton. The timber, evergreen-oak and spruce-pine, is abundant. There is plenty of water in wells and springs, and in Vulcan Creek.

The district has 300 inhabitants. A body of Mission Indians, 150 in number, live here. There are many kinds of game, including the deer, bear, rabbit, hare, quail, California lion, pigeon, gray squirrel, duck, goose, and wild hog.

CASTLE DOME DISTRICT, ARIZONA.

Information obtained by George H. Birnie, March, 1876.

Castle Dome district lies in the foot-hills and on the western slope of a range of mountains in Arizona, 18 miles east of the post-office of Castle Dome Landing, on the Colorado River. The eastern side of these mountains has not yet been prospected. The general trend of the range is north 25° west, with other ridges running at right angles to this direction. The district, as already traced, is 2 miles in width and 7 in length, following the trend of the mountains.

It was discovered and organized in 1863 by Messrs. Snively and Conner. Except a portion of 1872, it has been worked constantly since that time. The most practicable route thither is from Seven Palms railway station to Ehrenberg, 110 miles, and thence by river to Castle Dome Landing. Supplies may be sent to this point by the Colorado Steam Navigation Company. Mule-teams, for the conveyance of freight, run from the river to the mines. Cost of such transportation, $6 per ton.

A geological investigation has been made by Professor Blake, of Connecticut. The lodes are found to run north 25° west. Some follow and others intersect the stratification. The rich veins are found in fluor spar or talc. The wall-rocks are of mixed slate and porphyry. They are

perpendicular, with an east and west slope. Fissure-veins are found at a depth of 350 feet. The country rock is basaltic. No fossils occur.

The ores are worked by smelting and by the process of iron precipitation. The ores are galena, carbonate of lead, and anglesite. An average yield of $32 per ton in silver is obtained. Lead forms 67 per cent. of the ore. Iron is the other base metal. Traces of gold are found. Water has not yet been reached.

The principal mines are the Flora Temple, Castle Dome, William Penn, Caledonia, Don Santiago, Little Willie, and Norma. The general character of the ore is the same throughout all of these, except the Castle Dome and Caledonia, in which anglesite and carbonates are found. Their claims vary in extent from 200 feet by 1,000 feet to 600 feet by 1,500 feet, and lie in the foot-hills and the mountains above. From the main lodes about 6,000 tons of ore have been extracted and taken away for reduction, at an expenditure of about $200,000. On the Colorado River, 18 miles from the mines, the Castle Dome Smelting Company has a blast-furnace, with an engine of 20 horse-power. Its capacity is 20 tons per diem.

The cost of a furnace constructed at the mines would be $12,000. Other expenses average as follows: Cost per ton for mining the ore, $8; for reducing the same, $9; mining labor per diem, $2; smelting labor, $2; running a tunnel on main vein, $3.50; sinking a shaft, $4; running a drift, $3. One man can stope from one to five tons of ore per diem, according to the size of the vein, or can extract six tons per diem. Expense will be reduced by the completion of the Southern Pacific Railroad to the Colorado River.

There are a few horses, mules, and burros in the vicinity. There are no facilities for raising produce. Barley is worth $4 per hundred-weight. Alfalfa, wheat, corn, oats, sugar-cane, vegetables, cotton, fruits, and wild hemp can be procured at Yuma. The varieties of timber are cotton-wood, suwarrow, iron-wood, willow, and mesquite. Water is scarce, the nearest supply being a good well 10 miles from the mine. The deer, mountain-sheep, antelope, quail, rabbit, and hare abound. There are 200 inhabitants in the district, besides about the same number of Date Creek Apache Indians.

COLORADO DISTRICT, NEVADA.

Examined by Dr. O. Loew, July 31, 1875.

These mines are near the Colorado River, along the foot-hills of the Black Mountains, in some cases approaching the summit of the same. In area this district is 3 miles wide by 7 miles long. A small island in the Colorado River forms its approximate southeast corner. Saint Thomas is the post-office. San Bernardino, Cal., 300 miles distant, is the nearest railway station. Freight from that point is 8 cents per pound. By steamer from San Francisco it is $75 per ton. This would be reduced by the extension of the Fort Yuma and Fort Mohave steamboat route to this point, which is 80 miles above Mohave. The district was discovered in 1861 by N. S. Louis. It was organized in the same year, and has been worked at intervals since.

Previous geological investigations have been made by an assistant of Professor Silliman, in 1865; by the State geologist of Nevada, in 1869; and by a party of this survey in 1871. The direction of the mountains is north and south; of the lodes, northeast and southwest. The veins are very distinct from the wall-rock, and conform, in dip and strike,

with the slates in which they are situated. The gangue consists of quartz and calc spar, with talcose slate occasionally intermixed. The adjacent rock is azoic and volcanic. No shells are found. The neighboring mountains are largely made up of trachyte and rhyolite. Assays average $50 per ton. The ores are reduced by roasting and milling. In the roasting process, sulphur and salt are added. The salt is obtained from the extensive deposits in the valley of the Virgen River. Sulphur was recently discovered on the Muddy River.

The silver ores consist of sternbergite, with some argentiferous galena and copper glance. Chloride of silver has been found, but only at the surface of the lodes. Iron and copper pyrites occur with the silver ores. The principal base metal is iron. Copper and lead, with some antimony, are also present. Assays show the presence of gold in the silver-ores.

The principal mine is the Tekehetukup, whose vein is from 6 to 8 feet wide. Its shaft is 200 feet deep, with two levels, 200 feet and 264 feet in length. The ore is found in pockets of various sizes. The Queen City Lode contains galena in talc. Its shaft is 95 feet deep; its vein is 2 feet in width. There is one mill of ordinary structure, with roasting-furnace attached. The stamps make eighty drops per minute. There are four pans and two settlers in the works. The amalgam is strained cold. Up to date, about $100,000 has been extracted from one mine.

A 4-stamp mill, at the mines, will cost $1,500. Other expenses will average as follows: Mining the ore, per ton, $5; reducing the same, $25; mining labor per diem, $4; milling labor, $2.50; running a tunnel on main vein, $20; sinking a shaft, $25; running a drift, $15. One-half of a ton of ore can be stoped by one man in one day.

Grain is worth 7 cents per pound; hay, $70 per ton. Las Vegas, Nev., is the source of supply. Timber is very scarce. The Colorado River furnishes the requisite water. Mountain-sheep and rabbits are the principal kinds of game. There are about a dozen men in the district, besides a few Pah-Ute Indians.

CERRO GORDO DISTRICT, CALIFORNIA.

Examined by Dr. O. Loew, October, 1875.

The mines of the Cerro Gordo district are northeast of Owen's Lake, on the east and west slopes of the Inyo Range, which is the southern extension of the White Mountains. The district covers about 4 square miles. Its croppings are scattered over 800 acres or more. The trend of the mountains is northwest and southeast; of the district, the same. Its post-office is Cerro Gordo. It is 150 miles from Caliente, the present terminus of the railroad, with which it is connected by a freight-line; cost of freight, 5 cents per pound. The country roads are rough. This district was discovered in 1866, by Pablo Flores and companions. It was organized in 1867, and has been worked continuously since.

Previous geological examinations have been made by Clarence King, by the California Geological Survey, and by a former party of this survey. The lodes run northwest and southeast. The lead-veins, on the west side of the range, correspond with the stratification of the country rock, which is of Silurian limestone; the copper ores occur in syenite, on the east side of the mountains. The veins are true fissure-veins, in some cases contact-veins between limestone and slate. A thin seam of clay frequently covers the foot-wall. At times calcite and clay are found in the vein-matter, and these are intermixed with galena and the carbonates. The richest silver ores generally lie near the center of such

mixed veins. The mountains are largely made up of Silurian limestone. Encrinites are found in this in great numbers. Some spirifers also occur, but other fossil-shells are rare. Dikes of intrusive rock, such as diorite and syenite, abound, and the strata are much displaced, in some cases standing on edge. On the east side of the main peaks there are large foot-hills entirely made up of syenite, evidently of an eruptive character. Quartz-ledges, with stetefeldtite and chloride of silver, traverse this rock. This eruptive syenite consists chiefly of oligoclase, orthoclase, and hornblende, with quartz in small quantities. Signs of former glacial action are evident.

The ores are worked by the smelting process. The average yield is 400 pounds of lead and 60 ounces of silver per ton of galena, while the argentiferous copper ores give 75 ounces of silver per ton. On the west side of the main peak the ores are galena, massicot, cerussite, anglesite, and mimetite, accompanied by sulphide of arsenic. Cerargyrite and argentite occur, and nuggets of gold, in value from $60 to $100, have been found.

On the east side of the peak the ores are gray copper, stromeyerite, and copper glance, with some native silver and argentite. This ore, especially of the Buena Suerte lode, contains gold to the amount of $20 to $30 per ton. Iron, arsenic, antimony, zinc, lead, and copper are the base metals.

The principal mines west of Cerro Gordo Peak are the Union, whose lode is 12 feet in width, with a tunnel 600 feet long and a shaft 800 feet in depth; the Santa Maria, 6 feet in width, with which is connected the Omega Tunnel, 900 feet long, and a shaft 300 feet deep; the San Felipe, with a vein from 1 to 6 feet in width; the Ignacio, a wide quartz ledge, containing argentiferous copper glance and galena; and the Jefferson, with the Buena Vista Tunnel, 800 feet long. The ore of the latter lode is 35 per cent. lead and yields 80 ounces of silver per ton. It contains a number of "chimneys of soft ore;" carbonate of lead and massicot.

East of the peak are the Belmont, Wittekind, and Buena Suerte lodes. The ledge of the latter is from 2 to 5 feet thick, and contains bodies of ore which assay from $150 to $400 per ton. Its walls are slicken-sided. It has four tunnels, averaging 150 feet in length. The Potosi Tunnel, 4,400 feet long, to be completed in two years, at a cost of $97,000, is intended to connect with the leading mines at Cerro Gordo.

Altogether, about $5,000,000 of silver have been exported from this district since the introduction of machinery, some seven years ago. There are two smelting-furnaces; of simple construction, but no mills. The reduction-works have a working capacity of 8 tons. The lead and silver of the bullion are not separated here, but are sent elsewhere for cupellation. Great loss is sustained in smelting the ores, as hardly two-thirds of the assay yield is obtained in silver.

Mining expenses will average as follows: Extracting the ore, per ton, $50 to $100; labor, per diem, $4; running a tunnel on main vein, $10; sinking a shaft, $20; running a drift, $5. Owen's Valley and the San Joaquin Valley are the sources of supply for hay ($60 per ton) and grain, (5 cents per pound.) Some piñon and juniper timber grows on the Inyo range. There is no pine nearer than the Sierra Nevada, 60 miles distant. The water is supplied from a source 4 miles away, from which three powerful engines produce 10,000 gallons a day, lifting it 2,200 feet. The inhabitants of the district number 500, in addition to 100 Pah-Ute Indians. There is no game in the vicinity.

NEW ALMADEN MERCURY-MINES, CALIFORNIA.

Examined by Dr. O. Loew, May, 1875.

These mines are situated in the Santa Cruz Mountains of Santa Clara County. There is no regularly organized district, but the area covered by croppings is 3 miles long and 500 feet wide. They have been constantly worked since 1840, when they were discovered by the whites. Previous to this date the cinnabar obtained here was in use among the Indians as a paint. The post-office is called New Almaden. The mines are 12 miles from the railroad at San José, to which town a stage-line runs. Cost of freight from that point is $2 per ton. The roads are very good.

A geological investigation has already been made by Professor Whitney. The trend of the ore-bearing rock, like that of the mountains, is southeast and northwest. There are no regular veins. The cinnabar occurs in pockets and chunks in the ledge, which is partly serpentine and partly quartz, and as "impregnation" of serpentine, quartzite, and sandstone. The main rock in the vicinity is ferruginous sandstone. Tertiary strata extend along the foot-hills, but the mines and the adjacent rock are of greater age, probably azoic.

The ores are reduced by roasting, and the mercury distills over into chambers, where it condenses. Water is found at a depth of 300 feet. Cinnabar is the only ore met with. The principal mines are the New Almaden, with a shaft 1,200 feet deep and a tunnel 800 feet long; the Enriqueta, with a tunnel 700 feet long, and the Guadalupe, with a shaft 300 feet in depth. In 1874 the New Almaden Mine alone yielded 11,000 bottles of mercury, weighing 76½ pounds per bottle. There are 6 Postamente furnaces of old construction, with 18 condensing-chambers, and one Idria furnace of the latest style, with water-condensers. The condensing-chambers are of brick, communicating with each other by channels. They are about 30 feet high and from 10 to 15 feet in length and width.

There is but little timber in this region. The Alamita Creek furnishes the necessary water. Deer, quail, and rabbits abound. Domestic animals are abundant, and produce of all kinds is cheap. There are 3,000 people in the immediate vicinity.

U-BE-HE-BE DISTRICT, CALIFORNIA.

Examined by Lieut. Rogers Birnie, jr., October, 1875.

The deposits of this district lie about 72 miles a little north of east from Cerro Gordo, on the northern slopes of a spur of the Panamint range, which trends to the west nearly at right angles to the main range, and separates Panamint and Salinas Valleys.

Ore was first discovered here by William Hunter, of Cerro Gordo, on July 2, 1875. The district was organized July 8, 1875. There are now eight locations recorded.

The ores are principally carbonates of copper, containing more or less silver. The ledges run with the country-rock, northeast and southwest. The main ledge lies between limestone and granite, the outcrop showing for more than 2 miles. Mineral deposits are found through an extent of 10 miles.

Wood and water are scarce, and are brought a distance of 10 miles. Wood is obtained from the higher portions of the spur alluded to above; water comes from one of the tributary valleys of the Salinas.

Locations of mineral deposits, containing silver in quantity, have also been made in or near Grapevine Cañon, and named Armstrong district. None of these ledges have been developed, and very little work has been done.

The outcrop at the U-be-he-be district is encouragingly spoken of, but at present the region is not very accessible.

SUMNER DISTRICT, CALIFORNIA.

Examined by Douglas A. Joy, October, 1875.

This district lies about 1 mile north of Kernville, on the west side of the North Fork of Kern River, on the eastern slopes of the foot-hills leading down into the cañon of the same. Its post-office is Kernville. It is 40 miles to the railroad at Caliente, with which town it is connected by freight and stage lines. Cost of freight from that point, 1½ cents per pound. The roads are very good.

The veins are true fissure-veins, with slickensided walls. The wall-rock is granite. The adjacent country is of azoic formation. Ores are worked by milling and amalgamation. The average assay in the Sumner lode is $16 per ton. The bullion consists of 66 per cent. gold, 31 per cent. silver, and 3 per cent. of base metals. A newly-discovered lode, the Mineral King, is said to assay from $100 to $400 per ton in silver and $50 in gold.

In the Sumner lode the rock is principally a gold-ore. The quartz contains free gold, ruby silver, and pyrites. Antimony, arsenic, and iron are the base elements.

Water-level is reached at a depth of 118 feet. In the Sumner Mine the shaft is 290 feet deep, with 3 levels, each 300 feet in length. The vein is from 30 to 40 feet in width. A plunger-pump is connected with this mine. The vein of the Mineral King is 22 feet in width, and contains ruby silver and free gold. It was struck at a depth of 109 feet. Its tunnel is 50 feet in length.

At these mines there is one mill with 80 stamps and one with 16. Each stamp weighs 900 pounds, and makes 80 drops per minute. Each stamp will crush a ton of ore per day. There are six pans and settlers. Amalgam is strained cold. The mill is run by the water-power of Kern River.

Cost of milling and mining labor at Kernville is $3 per diem. Grain is 4 cents per pound. Good pine timber grows on the surrounding mountains. The water of Kern River is abundant and good. There are 1,200 inhabitants in the district, including Kernville. Domestic animals are numerous, and game is not scarce; the deer, bear, quail, and rabbit are found.

ROSE SPRING DISTRICT, CALIFORNIA.

Examined by Lieut. Rogers Birnie, jr., 1875.

This district is in the Panamint Range, between Panamint Valley and Death Valley. It is bounded on the north by Cottonwood Cañon and on the south by Rose Spring Cañon. The ledges lie in the main range and in the foot-hills and spurs which slope into Death Valley on the east. The district is of irregular shape. Its outcroppings and developments

are extensive. It was discovered by Joseph Nossano in 1873, and has since been worked continuously, but not vigorously. As early as 1860 antimony was mined in this region. Its post-office is Panamint. It is connected by wagon-road with Tate's station on the Panamint and Caliente stage and freight line. Its total distance from Caliente is 154 miles. A number of geological investigations have been hitherto made in this district.

The country-rock is of granite, slate, porphyry, and limestone. No fossils are found. The veins run with the country-rock, and are generally richest in the slate and porphyry, which are the predominant constituents. The trend of the mountains is north and south; of the veins, east and west.

The principal ores are chlorides, bromides, and sulphurets of silver; some fine specimens of horn-silver were found in the dump of the North Star mine. Traces of gold are noticed. But little smelting ore has been discovered. The free and wet processes are both used, but the wet milling ore is most abundant. Some of the ore is roasted. An average of the assays of eight mines in the district gave a yield of $919 per ton, silver.

There have been 154 locations made in the district. Some of the most important are as follows:

North Star Mine.—Vein about 2½ feet thick; trend, a little north of east; dip, 60°; free milling-ore; a contact vein, with walls of porphyry and slate; chloride is the most prominent ore.

Garibaldi Mine.—Vein 50 feet thick in places; trend, east and west; dip, 64°; milling ore, with trace of antimony and copper, and a small percentage of lead; hanging-wall, slate; foot-wall, probably metamorphic rock.

Annie Mine.—Incline 75 feet long; trend, northeast and southwest; ore, stromeyerite.

Polar Star.—Trend, north and south; shaft, 14 feet; cut, 20 feet; yield, chlorides and stromeyerite.

Maria.—Shaft, 20 feet; yield, chloride, native silver, and stromeyerite.

Star of the West.—Trend, north and south; dip, east; yield, stromeyerite; wall-rock, limestone and porphyry.

Nellie Grant.—Shaft, 35 feet; ore, chloride; trend, east and west; dip, north; wall-rock, slate or limestone.

Mary Ann.—Shaft, 5 feet; trend, north and south; dip, west; ore, stromeyerite; wall-rock, limestone and slate.

A 10-stamp mill, erected in the district, would cost $25,000. Cost for mining the ore, $4 per ton; mining labor, per diem, $4; running a tunnel, per foot, $15; sinking a shaft, $18; running a drift, $15. Expenses would be decreased by a railroad. Panamint is now the general source of supply. There are but few facilities for agriculture. There is but little stock in the vicinity, although there is grazing enough for a moderate number. In the southeastern part of the district timber is plenty. Water is scarce, being obtained from springs. Many of the mines are 4 or 5 miles from water. There are 25 inhabitants in the district, besides 30 Pah-Ute Indians. Mountain-sheep, rabbits, and deer abound.

AZTEC DISTRICT, NEW MEXICO.

Examined by Alfred R. Conkling, July, 1875.

The Aztec District, also known as the Creek District, is situated between Baldy Peak on the west and the Cimarron plains on the east.

One square mile will include the area marked by mineral croppings; half an acre will cover all the surface yet broken for mines. North and south is the general trend of the mountains from the main range, of which minor ridges and spurs project to the east. The district was organized in 1868, but placer-mining had been in progress prior to that time. It has been worked continuously. Its post-office is Ute Creek. The nearest railway town is Las Animas, 200 miles distant by wagon-road. Freight from that point is 3½ cents per pound.

The Aztec lode is in a wall-rock of slate and granite. Its direction is from northeast to southwest. The veins are quite irregular, and dip into the mountains. No fossils are found in the immediate vicinity of the ore-deposits, but just east of them cretaceous limestone occurs. The ores are worked by the wet process, without roasting. The average yield is $60 per ton, principally in gold. The ores are auriferous quartz, galena, chalcopyrite, malachite, pyrite, and calcite in rhombohedrons and in the form of geodes.

The water-level has not been reached. As the depth increases, the ore grows poorer. In the Aztec mine, which is the principal one, a depth of 180 feet has been attained. This was formerly worked by a company with mills, but it is now occupied by individuals, who reduce the ore in arrastras. The veins are 12 in number; branches join the main vein from the east and south. The width of the main vein is from 4 inches to 6 feet. Ore is found in pockets. The gulch-gold is worth $18.50 per ounce, mine-gold $17.

According to reports, which are not very reliable, a total amount of $1,000,000 has been extracted. In 1874, a sum of $15,000 was taken out, and about an equal amount in 1875. It is said that the placer-mines yielded $86,000 in 1869. When the mill was running regularly, 15 tons of ore were worked in 24 hours. It was a 15-stamp mill, each stamp weighing 400 pounds, and making 24 drops per minute. There were three pans, but no settlers. The amalgam was strained cold.

The cost of a 15-stamp mill, delivered at the mines, is $30,000. A smelting-furnace with one stack can be made for $500. Other expenses will average as follows: reducing the ore, $6 per ton by arrastra, or $3.50 by mill; mining labor per diem, $2.50; milling labor, $2; running a tunnel on main vein, $25; sinking a shaft, $18. Grain costs from 3 to 4 cents per pound; hay from $12 to $15 per ton. Facilities are favorable for all produce except grain.

Timber is plenty, and there is an abundance of good water. The country roads are good. The inhabitants of the district number about 60, besides wandering bands of Ute and Apache Indians. There are several varieties of game, including the deer, turkey, bear, and grouse.

On the west side of the mountains placer-mining is extensively practiced. The water is brought from the Spanish range, through a gigantic flume, 47 miles long, which was built at a cost of $250,000, and has since been sold for $20,000.

LOOKOUT DISTRICT, CALIFORNIA.

Examined by Lieut. Rogers Birnie, jr., August, 1875.

The mineral cropping of this district is found throughout the eastern slopes of the Argus range, from Darwin Cañon on the north to Shepherd's Cañon on the south. The trend of the range is north and south; of the foot-hills, in which the depoits mostly lie, east and west. The

district was discovered in May of the present year, by Jerome Childs. It was organized in July, and has been worked since that time. It may be reached from Caliente by following the road of the Cerro Gordo Freighting Company to Tate's Station, and thence to the district, distance 156 miles. Or another route is by way of the Olancha, Independence, and Caliente road to Darwin, 152 miles, and thence by pack-trail to the district, 12 miles.

As far as discovered, the lodes and deposits have no definite direction. They are found in a belt of limestone, 3 miles wide, which runs from north to south. The veins are richest in white limestone. When they approach the granite, the ore changes from galena to copper—galena in schist is found in the granite. The country-rock along the summit of the range, from Shepherd's Cañon to a few miles south of Darwin, is granite; thence to Darwin Wash it is slate. At an altitude of 5,000 feet limestone appears, and at irregular intervals on the eastern slope granite and limestone occur.

Some ores are reduced by smelting, others by the milling process. Galena is the principal product. The base metals are lead, iron, and a little copper. Assays from the mines on Lookout Hill average $150 per ton. The assay yield, in general, varies from $25 to $3,000 per ton. Iron is a constituent of some ores to the extent of 30 or 40 per cent. Gold is present, sometimes to an important degree, and 12 or 14 locations of gold ledges have been made. Some assays have shown $9,000. The iron sulphides are reduced by the roasting process.

About 60 locations have been made, most important of which are the Lookout, Minnietta, Modoc, Confidence, Minute Gun, Lone Star, Antelope, Bismuth, Capital, Royal Arch, and De Soto. The Lookout and Confidence, on the north side of Lookout Hill, run nearly parallel and a little north of east. The Modoc, on the south side, runs southeast. The ledges apparently bear toward the center of the hill. The Lookout and Minnietta contain galena that is nearly pure. Gray carbonate and chloride are also found in the Minnietta. Quartz shows most plainly in the Confidence. In general, a great amount of ore is in sight along the ledges, but the mines are not yet sufficiently developed to decide concerning the permanency of the vein. A granite vein thrusts out of the limestone at one-half mile below Silver Springs.

A ten-stamp mill, erected in the district, will cost $50,000. This would be greatly decreased by the completion of the Los Angeles and Independence Railroad. Cost of mining or milling labor per diem is $4. Cost of sinking a shaft is $10 or $12 per foot. Supplies are brought from the railroad at Caliente, and from Owen's River Valley, by way of Darwin. Timber is 8 or 9 miles distant. Water is obtained chiefly from springs. The Minute Gun Spring, above the principal mines, flows two inches of water, miner's measurement; Silver Spring, on a level with the mines, is of equal size, and the Lillian Spring yields one inch of water. Other supplies could be brought in pipes from Egan's Falls on the north, or Snow's Cañon on the south. There is but little game in the district. It is peopled by 40 persons. The roads are poor. No freight-lines are yet organized.

TEMESCAL TIN MINES, CALIFORNIA.

Examined by Lieut. Eric Bergland, May 4, 1876.

These mines, not worked at present, are in the southern part of San Bernardino County, on the southwestern slope of the Temescal Mount-

ains, about 7 miles from the village of Temescal. They may be reached most easily from the railway at Anaheim, or from Colton, a station on the Southern Pacific Railroad. A good road leads from the village up to the mines.

As the mines were abandoned, it was difficult to obtain information concerning them. Three shafts were found. As they were partially filled with water, their depths could not be ascertained. In one of these the water was 90 feet below the surface, and in the other two, 40 feet. The latter were closely boarded; the walls of the former were unprotected, but no tin-ore was visible near the top of the ground. The ore had been raised by windlasses worked by hand or by horse-power. One shaft is vertical, the others are inclined at angles of 65° and 75° to the horizontal.

The vein extends a considerable distance, and is said to appear in the range on the south side of the valley. Last winter one of the shafts was cleared of water, and five tons of ore were extracted and shipped to England. The ore is reported to contain 18 per cent. of tin.

Two houses and a blacksmith-shop had been built at the mines. In an adjacent valley water and a small patch of grass were found.

Economic Botany and Agriculture.—Dr. J. T. Rothcock, acting assistant surgeon, United States Army, submits a report on this subject, including portion of California, and the islands of Santa Barbara and Santa Cruz, which will be found interesting and instructive, especially to those who have not an intimate knowledge of the varied resources and productions of that region. (See Appendix H, 5.)

The report of Dr. Loew on the physical and and agricultural features of Southern California, the coast counties, island of Santa Cruz, and the Mohave Desert, valleys, oases, and soils, will add not a little to the interest attaching to the Pacific Coast. (See Appendix H, 6.) To the botanist, especially, will his notes on the geographical distribution of vegetation in the great Mohave Desert be of value. (See Appendix H, 7.)

Zoölogy.—Mr. H. W. Henshaw, who has been connected with the survey for several years, presents a report upon the results of his observations and collections. (See Appendix H, 8.) Mr. S. H. Scudder, of Cambridge, Mass., kindly consented to examine the specimens of orthoptera collected during the season, and his report thereon is herewith. (See Appendix H, 9.) Dr. John L. Le Conte cordially consented to examine the collection of coleoptera, and his classified report is appended. (See Appendix H, 10.) Lieut. W. L. Carpenter submits a report on the Alpine insect fauna of the Rocky Mountains. (See Appendix H, 11.)

Mr. Henshaw presents some notes upon the mammals taken and observed in California during the season. (See Appendix H, 12.)

Ethnology.—Dr. H. C. Yarrow, acting assistant surgeon, United States Army, was placed in immediate charge of a special party for the purpose of making ethnological researches in the vicinity of Santa Barbara, Cal., and his report, prefaced by an historical account, as given by Cabrillo, a Portuguese, who visited this coast in 1542, is appended. (See Appendix H, 13.) The collection obtained by this party by excavating in mounds and graves is of varied interest, and the examination of and report upon the same by Prof. F. W. Putnam, curator of the Peabody Museum of Archæology, will, when it appears in Volume VII of the survey reports, it is believed, prove a considerable addition to the early history of this section.

Dr. Loew also submits a report of an ethnological character, regarding

the Indian tribes visited, their customs and relations, &c. (See Appendix H, 14.)

Dr. O. Loew presents a report upon the physiological effects of a very hot climate, which, while somewhat foreign to the general subjects of investigation by the expedition, may yet, as stated by him, be one "deserving attention in connection with the exploration or occupation of the Colorado Valley, and one not heretofore treated upon to any great extent." (See Appendix H, 15.)

Philology.—Mr. Alb. S. Gatchet has examined several vocabularies collected by members of the expedition, and presents an analytical report upon idioms spoken in Southern California, Nevada, and on the Lower Colorado River. (See Appendix H, 16.)

PUBLICATIONS.

During the year the following maps have been published:

Progress Map.

Crayon Atlas Sheets 49 and 67.

Geological Atlas Sheets 50, part of 58, and 66, 59 and 67, 75 and 83.

Map showing restored outline of an ancient fresh-water lake, ("Lake Bonneville.") Geological Atlas title-sheet.

Topographical Atlas Sheets 61 B, 61 C, 61 C, (sub.,) 69 D, 75, 76, and 83.

And the following reports:

Preliminary Report, 1869. (Revised edition.)

Volume III, (Geology.)

Volume IV, (Paleontology.) Part I. Invertebrates.

Volume V, (Zoölogy.) (Not ready for distribution.) Progress has been made upon Volumes I, II, VI, and VII, and it is expected to have the MS. of three of them in the hands of the printer by January 1, 1877. The manuscript for Catalogue of Declination of 2,018 stars has gone forward.

DIVERSION OF THE COLORADO RIVER.

By Department letter of May 6, 1875, in addition to the regularly organized work of the season, a special preliminary examination as to the feasibility of diverting the waters of the Colorado River of the West for purposes of irrigation was authorized, and, as stated in my last annual report, Lieutenant Bergland was intrusted with the charge of a separate party for this purpose.

Both a summer and a winter trip were made. In submitting his report, Lieutenant Bergland, after describing the organization of the party, the routes followed, and discussing the question of the diversion of the river, decides, as the result of his first trip, that it cannot be successfully done at any point between the foot of the lower Grand Cañon and the head of the Colorado Valley, an approximate distance of 326 miles, because of the outlying ridges with high passes, through some of which the river has cut its way; and as a result from his second trip, he concludes that no such diversion can be successfully made at any point along the present channel of the river within the territory of the United States.

As shown in my report to the Chief of Engineers of April 27, 1875, in pursuance of a communication of Mr. E. F. Beale to the President, under date of March 20, 1875, no diversion of the river on a large scale could practically be made between the junction of the Green and Grand rivers and the point of its emergence from the Grand Cañon, near which

Lieutenant Bergland began his survey. He has examined the general course of the river for a distance of 326 miles, and caused sections to be made near the mouth of the Virgin and Camp Mohave. Observations were made at Liverpool Landing and about Fort Yuma, with profiles from Fort Yuma westward to the depressed area near Indian Wells, and from Algodones to the westward, in vicinity of the bed of New River, so called. The volume of water measured at Stone's Ferry, near the mouth of the Virgin, was found to be, in August, 1875, approximately 18,410 cubic feet per second, or sufficient in amount to irrigate 3,682,000 acres, assuming one cubic foot per second for each 200 acres.

At Camp Mohave in September the flowage was 8,680 cubic feet per second, or sufficient at the assumed rate for the irrigation of an area of 1,736,000 acres. At Fort Yuma in March, 1876, the volume of water was found to be 7,658 cubic feet per second, sufficient for the irrigation of 1,531,600 acres. The estimate of the volume of water necessary for the irrigation of a single acre for one crop, (one two-hundredth part of a cubic foot per second, used 200 days,) is taken from the report of the commissioners, Messrs. Alexander, Mendell, and Davidson, upon the irrigation of the San Joaquin and Tulare Valleys of California. By assuming the increased area of the cross-sections of the river at high water as shown by the section made at Stone's Ferry, the velocity of discharge remaining the same as that noted as the mean velocity at that point in August, the increase of the volume of discharge would be 31,439 cubic feet per second, making the total volume of discharge nearly 49,849 cubic feet per second, or a little less than three times the volume observed in the middle part of the heated season. Could this amount be utilized upon ordinarily compact soil, which, however, is partially impracticable, approximately 10,000,000 acres of land could, by its instrumentality, be brought under cultivation. The increase of discharge upon the assumption of a mean velocity at high water, the same as that observed in September at Camp Mohave, would give 34,274 cubic feet at that point; because of the large area of bottom-lands overflowed at high stages, the velocity would be increased but slightly.

At Fort Yuma the increase, on account of estimating with increase of cross-sections of the river at these points, as shown by cross-section, assuming an unchanged mean velocity, would be 14,244 cubic feet, giving nearly a double volume of flow, while at Camp Mohave it is tripled, and at Stone's Ferry nearly doubled.

Lieutenant Michler, while engaged upon the Mexican Boundary-Survey in the winter of 1854–'55, estimated the volume of discharge at the

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NOTE FROM MEMORANDA OF LIEUTENANT BERGLAND.—At Stone's Ferry and Fort Yuma it is seen that the increase in discharge corresponding to the observed high-water marks is about double that of the measured discharge, while the increase at Camp Mohave is three times that of the measured discharge.

As the highest observed water-marks given at the three places do not belong to the same year, no direct comparisons can be made as to the increase in discharge, but it is highly probable that the large approximate increase at Camp Mohave is nearer the true increase than that at the other places, since at Camp Mohave the velocity would not be greatly augmented, while at Stone's Ferry there must be a considerable increase in the mean velocity due to the rise. This increase of velocity would be less at Fort Yuma, since a portion flows outside the sections, but it would be much greater than at Camp Mohave.

Fort Yuma, Cal., March 20, 1876.—Area 2,726.5 square feet. Width 461 feet. Hydraulic radius or mean depth 5.85 feet. Mean velocity 2.809 feet per second. Discharge 7,658.74 cubic feet per second. High-water mark of 1862 above surface of river 10.19 feet. Increase of area of section at high water, 5,059 square feet. It is to be noted that when the water reaches high-water mark of 1862 the bottom-lands are more or less flooded, and all the water does not pass through the section. The high-water marks given are the highest observed at each place. Increase in discharges

junction of the Colorado and Gila Rivers 6,249 cubic feet per second, with a velocity of 3 feet per second. The estimated evaporation at Camp Mohave as given by Lieutenant Bergland, deduced from observations extending over a small interval, is a little less than 8 feet; this would be increased at Yuma, while at Stone's Ferry it would be similar in amount.

A lake required to contain the influx of all the waters of the river at the stage mentioned near Fort Yuma, the only point near which it can be diverted, would be somewhat less than one thousand square miles. The area of depressed region (approximately) to which a channel can be cut from the river is 1,600 square miles. Hence, it appears that during the low-water stage this lake would act as a reservoir without outlet, while at a high stage the overflow at its maximum would cause a regular channel to be cut, making its own outlet to the gulf and forming along its route a series of lagoons during seasons of no flood, or the greater part of each year; but should it be possible to introduce waters from the gulf to the lake thus to be formed in the depressed area, the same would be transferred into a tidal lake with a current setting in toward the gulf by way of the conduit thus formed, receiving fresh waters from the river and affected by the changes of the high and low-waters from the sea. No change of climate can be expected to ensue from the formation of a lake or number of lakes, aggregating the above area. The amount of evaporation from the surface would be insufficient to change noticeably the relative humidity of the surrounding atmosphere, while the prevalent winds, both from local and far-distant sources, would diffuse and disseminate the amount of moisture thus received with great rapidity. The soils along portions of the route, as shown by Dr. Loew's report, (see Appendix H 6,) are, many of them, of an arable nature, needing moisture only to be made productive.

In the lower parts of the valley of the Colorado, cotton, coffee, sugar, tea, and flax could undoubtedly be grown with success, while a small change for the better in the relative humidity at local points could most likely be brought about by planting the eucalyptus, and trees of like strength of foliage, along the narrow valleys bordering the river. The mulberry could also doubtless be made to flourish. The unfortunate climate to which this portion of the Southwest is at present treated by the hand of nature is likely to retard its rapid settlement, even if water was plentifully available; still at some future time in the settlement of

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through section = 14,244 cubic feet per second. Here the velocity throughout the section would be increased at time of high water, and a large quantity would flow outside of the section.

Stone's Ferry, Nevada, August 12, 1875.—Area of section = 5,723 square feet. Width = 480 feet. Hydraulic radius, or mean depth = 11.89 feet. Mean velocity = 3.217 feet per second. Discharge = 18,410.38 cubic feet. High-water mark of 1871 is 17.01 feet above surface of water at time of observations. Increase of area at high water 9,773.1. The whole discharge at high water takes place through the section. Supposing the mean velocity to remain the same as August 12, 1875, the increase in discharge would be 31,439.7 cubic feet per second; but as in reality there would also be an increase in the velocity, the increase in discharge would be somewhat greater than this, but how much greater cannot be determined without direct experiments.

Camp Mohave, A. T., September 2, 1875.—Area of section = 4,628 square feet. Width 1,116 feet. Mean depth (hydraulic radius) = 4.144 feet. Mean velocity = 2.508 feet per second. Discharge = 11,610.93 cubic feet per second. High-water mark of 1874 above surface of river = 8 feet. Increase of area of section at high water 13,655.89 feet, (excluding overflow on flats.) Increase in discharge through the section would be 34,274 cubic feet, but as a considerable quantity of the bottom beyond the section is then covered with water, this will not represent the total increase. Here there would be but slight increase in the velocity, as the water has a chance to spread over the bottom-lands, (see plot of section.)

S. Peters, Photo Lithographer, Washington, D.C.

the West, each cubic foot of the waters of the Colorado is likely to become valuable in agricultural, mining, or other pursuits.

The topographical data obtained by Lieutenant Bergland's party, as partially shown by the sketches herewith, (see Appendix B,) although apparently meager, is yet sufficient to illustrate the route of the party and to locate the principal points referred to in the report. It will all be incorporated in the regular atlas maps covering the regions traversed, to which it will prove a valuable contribution. A sketch of the region south of latitude 37° 20′ is here introduced, showing the diversion between the direct coast-drainage and that forming part of the great valley of the Colorado and of the interior basins, those lying in California and Nevada. The total number of square miles shown is 104,300, of which 88,300 square miles approximately belong to California, and 16,000 square miles to Nevada; 42,600 square miles of this area is a part of the great valley and coast drainage, or 48 2-10 per cent. Of the remaining area about 45,700 square miles, of which less than 2 per cent., is now arable, or could be made arable with all the water available within its limits. Of the amount constituting the coast and valley drainage, allowing that 60 per cent. can be made valuable for agricultural purposes, (an amount presumedly largely in excess of what would be found to be true after a rigid examination and survey of these areas,) it appears that of this portion of California south of latitude 37° 20′, only 29.4 per cent. can ever, with the best facilities, be made useful for agricultural purposes. The area in California of a desert character, the 45,700 square miles above mentioned, is much larger than the area of the same character in Arizona, the latter having been charged as the acme of the desert of the United States, whereas the Great Colorado plateau and plauteau-ridges about the upper waters of the Salt and Gila Rivers, and the sources of certain minor streams, as the San Pedro and Santa Cruz, are sections that are quite the reverse of deserts. While the southwestern portion of Arizona must always remain sparsely inhabited because of its want of water and stretches of sandy waste, yet the amount thus withdrawn from all hope of settlement, except at little water-stations, is comparatively less than the desert portion of California lying south of latitude 37° 20′ N., as shown by the sketch. This statement will in no wise invalidate the claims of the remainder of this great State to the rank it has so well taken among the greater grain-producing States of the Union, no more than it accuses nature in being wanton in the disposition of its fields for the uses of mankind.

That part lying east of the summit of the Sierras, where the rainfall immediately changes from one as great as 40 to 50 inches to 6, 8, and 10 inches annual fall, is not included, and is in addition to the area of 45,700 square miles mentioned. The part of Nevada shown is that portion least inhabitable from an agricultural point of view. While in all these desert sections mines have been and are still being found, oftentimes in sufficient proximity to water to warrant their being worked, still little underground exploration, even, has been undertaken, except in a few localities. Roads across this section of the country have been few, and the danger of exploring away from the main ones is the principal hinderance to the hardy prospector in his labors. Dr. Loew speaks of the wonderful change noticed by every traveler in crossing the summits of the Coast range south of Tehachipi Pass, found to exist between the desert and coast flora. This report will doubtless prove interesting. (See Appendix H 7.)

The basin drained by the Colorado River of the West comprises approximately 241,965 square miles, or approximately 154,857,600 acres,

composed of valley, plateau, and mountain section in wonderful variety, portions of which have been laid out into the following political divisions: California, Nevada, Utah, Wyoming, Colorado, New Mexico, and Arizona; and prior to its exit into the Gulf of California it washes the eastern shore of Lower California and the western shore of part of Northwestern Mexico. The length of the river from the junction of the Grand and Green is approximately 875 miles. Its elevation at Hanlon's Ferry, near Fort Yuma is 120 feet; at the grand bend to the south, near head of Black Cañon, 900 feet; at the junction of the Green and Grand rivers, 3,860 feet, from whence the name Colorado begins. It is essentially a cañon river until it leaves the territory of the United States, when its character in this regard materially changes, and with it the peculiarities of erosion and alluvial depositions in vicinity of its shifting bed, while opportunities for diverting the same are more likely to be found. The climate along its banks varies partly with the elevation, but more largely with the amounts of rainfall, which, until reaching the Grand Cañon, may be said to vary from ½ to 10 inches annually. In portions near the sources of Grand River, in the high, mountainous regions of Colorado, the rainfall increases somewhat in proportion to the altitude, and without any specific data on the subject it is safe to say that it reaches 40, if not a larger number of inches annually; but the areas showing the larger amounts of precipitation are comparatively small, and confined to the narrow valleys of the main stream and their side branches within the mountainous portions proper. No such amount of rainfall is known in any part of the Green River Basin, even at its source. Very little of this valley is available for agricultural purposes, and it would be difficult to improve large tracts of land along the main stream or any of its immediate tributaries. The districts, then, into which the entire valley-drainage of the Colorado area may be divided are as follows:

First, the more desert parts, bounded on the east by the western mesa wall of the Lower Grand Cañon, which is limited in extent on the north by the rim of the great interior basin near the Nevada and Utah line, and extending southward by the heads of the Salt and Gila rivers to the continental divide. Within this area there are strips of considerable size not desert, but diversified between mountain and desert, the northern portions of which, especially in the vicinity of the Salt and Gila rivers, are susceptible of cultivation, forming some of the finest grazing-fields in the world, with large patches of pine and other timber, and admitting of considerable settlement. Ridges traverse these portions, those running north and south being usually mineral-bearing, that have been prospected, but can scarcely be said to have been worked for the precious minerals.

The next is the plateau and cañon district, which has been delineated along its western line in the earlier reports and maps of the survey, the eastern limit running along the continental divide north as far as latitude 37°; from that point to the mouth of the Green and Grand rivers, thence in a nearly due west line to the great mesa-wall, passing northward of the Lower Grand Cañon, with an arm of the great interior basin in the vicinity of latitude 38° and longitude 113°, approximately.

The third portion is the province of the mountains, with their outlying foot-hills, being the basins, respectively, of the Green and Grand rivers, whose peculiarities have been noted by earlier explorers, and are being examined from time to time by Government parties.

The first or desert province is approximately 72,889 square miles; the

plateau province approximately 83,986 square miles; the mountain province approximately 85,190 square miles.

The majority of the land within the drainage of this river and its tributaries is still owned by the Government. The uses to which it may be applied must be confined largely to grazing and mining purposes, while local spots will admit of cultivation by irrigation process, in connection with the gradual development of the country, yet the husbanding of water becomes a matter of great import to all those who may at some future time occupy this portion of our interior domain. For a distance of 435 miles from the junction of the Green and Grand rivers it traverses territorial domain; and all that part of the Grand River still traversing public lands, as well as the basin of the Green River, is now owned by the Government, with few exceptions, and the disposition of its waters is a subject over which the General Government should assume entire control.

Legislation may be had defining more clearly and with greater certainty the rights of persons settling along the banks of main and tributary streams. It will be seen that the amount of precipitation, except in the mountainous province, is very small, and that little which is collected and, for which the river is the main channel of discharge, should be utilized in the most efficient manner. That can only be done by using its waters, so far as practicable, upon the land along its banks and within the immediate valleys adjacent thereto, and by artificial reservoirs. The measurement of the waters of this stream at proper points within the three provinces is a matter of importance, and the same should be ordered at an early day, so that the volume of water that could be made available for irrigation at stated intervals of the year, and especially during the seasons best adapted to crops, might become known, to the end that general legislation could direct the *pro rata* uses of the same for purposes of irrigation, when needed by actual settlers who have acquired title from the Government, or who are about to do so in pursuance of the homestead-laws. There being no law upon this subject to protect the rights of settlers upon streams as against prior occupants, nothing now prevents the diversion of the water of any stream, not alone of this great river above the head of navigation, but of all those flowing through Government lands in this and all other drainage-basins of the Western States and Territories, by interested proprietors, whose *locus* may have been selected at the point most likely to control the maximum of the waters of the immediate water-shed. It has been decided that water-rights guaranteed to settlers under the law of July 26, 1866, (Revised Statutes, p. 432, sec. 2339,) by a late opinion of the Supreme Court, rendered in the case of Basey *vs.* Gallagher, may inure under certain conditions. (See the American Law Times and Reports, March and April, 1875, for decision of the court.) The conditions of the case in question are best shown by the following extracts from the brief of the case, viz:

"4. In the Pacific States and Territories a right to running waters on the public lands of the United States for purposes of irrigation may be acquired by prior appropriation as against parties not having the title of the Government. The right exercised within reasonable limits, having reference to the condition of the country and the necessities of the community, is entitled to protection. This rule obtains in the Territory of Montana, and is sanctioned by its legislation.

"5. By the act of Congress of July 26, 1866, which provides 'that whenever, by priority of possession, rights to the use of water for mining, agricultural, manufacturing, or other purposes have vested and accrued, and the same are recognized and acknowledged by the local customs,

laws, and decisions of courts, the possessors and owners of such vested rights shall be maintained and protected in the same,' the customary law with respect to the use of water, which had grown up among occupants of the public land under the peculiar necessities of their condition, is recognized as valid. That law may be shown by evidence of the local customs, or by the legislation of the State or Territory, or the decisions of the courts. The union of the three conditions in any particular case is not essential to the perfection of the right by priority; and in case of conflict between a local custom and a statutory regulation, the latter, as of superior authority, will control."

And portions ofthe opinion as delivered by Justice Field:

"The questionon the merits in this case is whether a right to running waters on the public lands of the United States for purposes of irrigation can be acquired by prior appropriation as against parties not having the title of the Government. Neither party has any title from the United States; no question as to the rights of riparian proprietors can therefore arise. It will be time enough to consider those rights when either of the parties has obtained the patent of the Government. At present both parties stand upon the same footing; neither can allege that the other is a trespasser against the Government without at the same time invalidating his own claim."

* * * * * * *

In the case of Tartar *vs.* The Spring Creek Water and Mining Company, decided in 1855, the supreme court of California said: "The current of decisions of this court go to establish that the policy of this State, as derived from her legislation, is to permit settlers in all capacities to occupy the public lands, and by such occupation to acquire the right of undisturbed enjoyment against all the world but the true owner. In evidence of this, acts have been passed to protect the possession of agricultural lands acquired by mere occupancy; to license miners; to provide for the recovery of mining claims; recognizing canals and ditches which were known to divert the water of streams from their natural channels for mining purposes, and others, of like character. This policy has been extended equally to all pursuits, and no partiality for one over another has been evinced, except in the single case where the rights of the agriculturist are made to yield to those of the miner where gold is discovered in his land. The policy of the exception is obvious. Without it the entire gold region might have been inclosed in large tracts, under the pretense of agriculture and grazing, and eventually what would have sufficed as a rich bounty to many thousands would be reduced to the proprietorship of a few. Aside from this, the legislation and decisions have been uniform in awarding the right of peaceable enjoyment to the first occupant, either of the land or of anything incident to the land." (Per Heydenfeldt, J., 5 Cal., 397.) The case here laid confirms the occupant by possession as against the parties subsequently appropriating the waters under like conditions, and declares the doctrine which must determine, in other cases of occupancy after perfection of title, a more thorough and complete recognition of the rights to a specified amount of water, because of prior appropriation, which amount can be limited by nothing short of the entire volume of discharge. That this right has been claimed and maintained, to the detriment of incoming settlers, in the State of California, is well known. The difficulty arises because of the actual severing of the water from the land, its natural bed and mate, by legislation looking to the protection of settlers and other owners in their vested rights, real or supposed.

NOTE.—I am indebted to Hon. Montgomery Blair for reference to the decision of the Supreme Court regarding water-rights under the law of 1866.—G. M. W.

Unless this can be remedied, it is plain that the area west of the one hundredth meridian, and, indeed, still other areas lying between this line and the Mississippi River, cannot be settled except at local points, which will be selected principally because of the opportunities to use the entire water-supply with the greatest certainty, and the several tracts will thus fall into the hands of speculators and other large holders, to the detriment of that class of settlers most likely to enter and occupy these outlying lands, and establish the nuclei of a continuous cordon of settlement from east to west through the entire interior; small settlements though they might be, still they would be susceptible of a healthy increase by immigration, provided that the rights to each settler of an equable distribution of the water should be guaranteed by law. This cannot, however, be completely accomplished, until the gauging of the streams and measurement of the outlying districts are made by meandering the water-sheds, estimating the geographical conditions of each, bringing all into districts arranged according to the physical configuration of the country—the division being usually made by drawing lines normal to the general course of the main stream at each point selected for observation—and by determining the arable and arid portions within these districts, with the general profile of the country, a law could finally be framed that would provide for the entire equable distribution of the waters within each basin or water-shed. To this end it is suggested that, at an early day, the gauging of the rivers and principal creeks be commenced, not alone in the valley of the Colorado, but in all the basins of drainage of the entire western country. This can only be done by establishing a certain number of stations that can be made meteorological stations, furnishing a part of their data for the use of the Weather Bureau, when they can be reached by telegraph, and at which the gauging and changes in the streams can be ascertained, as well as the areas of the water-shed and the source of the main stream, with profiles of lines of irrigation-canals, and marked depressions fitted for storage-reservoirs, with estimates of evaporation, while the amounts of arable and timber and grazing sections can be determined by the moving field-parties engaged in the prosecution of geographical surveys, so that prior to actual occupation an exact knowledge can be had of the amounts of water needed to irrigate certain classes of soils in the several localities. That this can be done in connection with the prosecution of geographical surveys of the interior, with comparatively little increase of expense, is patent to me, and a plan looking to the initiation of such additional work can be submitted at any time; should appropriations be sufficient, and authority granted, the same may be taken up during subsequent seasons.

SUMMARIZED HISTORY OF THE SURVEY.

The following is a brief summarized history of the various points bearing upon the development of this work:

The officer at present in charge, while serving upon the staff of Brig. Gen. E. O. C. Ord (commanding Department of California) in 1869, conducted a reconnaissance looking to the development of routes of communication through Southern and Southeastern Nevada. While completing the results of that work, in compliance with instructions, a project was presented for the prosecution of similar work in other portions of the Military Department of California. In 1870 this work was suspended, owing to lack of funds. In the early spring of 1871 it was re-organized, and funds from appropriations for "surveys for military defenses" and other sources were placed at disposal for its prosecution in Nevada, California, and Arizona. The expedition of

this season was disbanded at Tucson, Ariz., and certain of its members ordered to Washington to prepare the necessary results. In 1872, fresh means having been appropriated by Congress, a more complete organization was had. The operations of this season were confined to a lesser area, principally in Utah, partially in Arizona and Southeastern Nevada. In 1873, the expedition was again sent into the field, and the character of the work was advanced measurably, in pursuance of the policy of perfecting the methods needed in a fully-developed geodetic survey of the entire western mountain region. During the season of 1873, in order to complete and connect the work extending from Nevada, Eastern California, and Northern Arizona to the east base of the Rocky Mountains, it was found essential to occupy points easily accessible by railroad-communication from the east. In 1874, connection between the eastern and western portions of the work was made more complete. The scheme of triangulation, based upon the positions of the several astronomical points determined along the east base of the Rocky Mountains, and the bases developed and measured therefrom, was extended to the west. In 1875, the survey for field-operations was organized in two divisions, designated respectively as the California and the Colorado sections. The Colorado section operated to extend the work in Colorado and New Mexico, begun in 1873 and further prosecuted in 1874, while the operations of the California section were laid in portions of the Southern Sierras and that branch of the coast range or ranges lying south of latitude 37°, and extending toward the Colorado desert southward of San Gorgonio Pass. One party was charged with an examination of the Colorado River, looking to a determination of the possibility of its diversion from its present channel for purposes of irrigation.

The area occupied by the survey, and lying mostly south of the fortieth parallel, is as follows:

	Square miles.
The part lying in Nevada	58, 940
The part lying in California	40, 625
The part lying in Arizona	60, 120
The part lying in Utah	44, 015
The part lying in Colorado	37, 550
The part lying in New Mexico	53, 236

Points have been determined by astronomical means in Nebraska and Montana.

The maps issued up to the present date represent an area of square miles as follows:

	Square miles.
On a scale of 1 inch to 8 miles	192, 217
On a scale of 1 inch to 4 miles	13, 028
On a scale of 1 inch to 2 miles	1, 091

CONCLUSION.

In submitting the report for the year it is deemed proper to invite attention to the area covered by the survey in relation to the total area west of the one hundredth meridian, for which a detailed atlas is proposed as the final result.

It may not be improper to speak of the position that the work has reached, as regards its methods, *personnel*, class of instruments, &c., resulting in an organization prepared for service in any portion of the entire territory west of the one hundredth meridian. Officers of the Corps of Engineers and line of the Army, being subject to changes of assignment whenever the exigencies of the service may require, cannot be considered as permanent assistants for a term of years; while most of the civilians whose

services prove satisfactory can only be retained provided continuous appropriations for the field and office work are kept up.

The supply of instruments of that character calculated to be used for the class of observations needed for work in the mountain regions increases year by year, and the resulting accuracy of the work due to the improvements in those employed, and the experience of the observers, renders each year's results more and more satisfactory. Unfortunately, during the long session of Congress, inasmuch as the work of the survey must be conducted during the summer months, (except in cases where it should be advisable to send an expedition to Southern New Mexico or Arizona,) no preliminary arrangements other than of a very meager character can be made for the expedition of a season until action by Congress. Hence each season's field-work is liable to be limited.

Should estimates be asked for looking to the completion of the entire survey after a certain fixed and definite standard, and with an organization selected for this express work, its systematic and vigorous prosecution would be heightened, should the same receive the approval of Congress and obtain a certain reasonable annual appropriation for its continuation.

As the season of 1877 may be made a long one, it is submitted that in order to complete it the amounts estimated should be appropriated for in full.

ESTIMATES.

For continuing geographical survey of the territory of the United States west of the one hundredth meridian, for the fiscal year ending June 30, 1878, being for field and office work	$95,000 00
Distributed as follows:	
For parties in the field	40,000 00
For office force	13,920 00
For transportation and purchase of animals	10,000 00
For material and outfits	6,500 00
For subsistence in the field	6,000 00
For forage, winter herding, fuel, storage, &c	9,500 00
For repairs of instruments	1,500 00
For contingencies, (erection of observatories and monuments at astronomical and geodetic stations, &c.)	7,580 00
Total	95,000 00
For preparation, engraving, and printing the maps, charts, plates, cuts, photographic, plate and other illustrations for reports, and for additional office-room in Washington, for fiscal year ending June 30, 1878	25,000 00

FINANCIAL STATEMENT.

Amount remaining unexpended from the appropriation for continuing the geographical survey of the territory of the United States west of the one hundredth meridian, for fiscal year ending June 30, 1876	$2,214 75
Amount remaining unexpended from the appropriation for engraving and printing the plates and atlas sheets accompanying the report of the geographical surveys west of the one hundredth meridian, for fiscal year ending June 30, 1876	10,217 86
Amount appropriated for continuing the geographical survey of the territory of the United States west of the one hundredth meridian, for the fiscal year ending June 30, 1877	20,000 00
Amount appropriated for preparing, engraving, and printing maps, cuts, plates, charts, and other illustrations for reports upon the geographical survey of the territory of the United States west of the one hundredth meridian, for the year ending June 30, 1877	10,000 00

All of which is respectfully submitted.

GEO. M. WHEELER,
First Lieut. Corps of Engineers, in charge.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

APPENDIX A.

EXECUTIVE AND DESCRIPTIVE REPORT OF LIEUTENANT WILLIAM L. MARSHALL, CORPS OF ENGINEERS, ON THE OPERATIONS OF PARTY NO. 1, COLORADO SECTION, FIELD-SEASON OF 1875.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., April 15, 1876.

SIR: I have the honor to submit the following executive report of the operations of party No. 1, Colorado section of the expedition for geographical surveys west of the one hundredth meridian, during the past field-season, together with a brief description of the topography and resources of the region surveyed and profiles of present and prospective routes of communications within this area.

PART I.—EXECUTIVE REPORT.

The Colorado section of the expedition consisting of the parties under the command of Lieut. W. L. Carpenter, Ninth United States Infantry, C. C. Morrison, Sixth Cavalry, and myself, was organized at South Pueblo, Colo., in the early part of June, 1875, and the area proposed by you for survey subdivided among the three parties as follows:

To Lieutenant Carpenter was assigned the completion of the triangulation partially measured the previous year along the Spanish and Raton ranges, south of the latitude of Fort Garland and north of Santa Fé, with certain portions of atlas-sheets 69*d* and 62*c* which had not been sufficiently examined the previous season, with directions to rigidly correct by triangulation the bases measured under your direction in 1874, at Trinidad, Fort Union, Las Vegas, and Santa Fé, and to make careful barometric profiles of all present or prospective routes across the southern extension of the Sangre de Cristo range between Fort Garland and Santa Fé. In addition to the executive charge of the party, Lieutenant Carpenter was assigned as naturalist to this party, and directed also by your instructions to make such paleontological collections in the field discovered by Prof. E. D. Cope in 1874, in the San Juan basin, as opportunity and time would admit.

Lieut. C. C. Morrison, in accordance with your recommendations, was instructed to complete the survey of such portions of the San Juan range south of the headwaters of the Conejos as were left incomplete the preceding year; to seek for a wagon-route from the valley of the Rio Chama near Tierra Amarilla, via the Washington Pass and the headwaters of the Bonito, to the west, and to complete the survey of the atlas-sheets 69*c*, 76*b*, 77*a*, 77*b*, and 78*a*, already partly surveyed. This programme necessitated long and rapid marches over areas already surveyed, to such isolated and in many cases almost inaccessible tracts which had been passed by in former years by parties of the survey on account of their rough character and the lack of water and grass for their animals. I respectfully refer to the reports of those officers, who do not report through me, for information as to the detailed manner in which those general instructions were carried out. To each of the above parties were assigned one field-astronomer, one topographer, one barometric observer and recorder, one aneroid and odometer recorder, and the necessary number of packers and cooks.

Each were provided with one sextant and artificial horizon, one triangulation-instrument reading to 10″ of arc by Vernier, one topographer's transit reading by Vernier to 1′ of arc, one odometer-vehicle and three odometers to be used in connection with the topographer's transit and the aneroid in meandering and profiling the roads, hand-compasses for meandering unimportant drainage-lines, two sets psychrometers, two cistern-barometers, two aneroids and pocket-thermometers for the use of such persons as require them, and with the necessary ruled and headed blank-books and forms for properly recording their observations; printed instructions as to the use of books and instruments and as to the methods of survey to be followed, accompanying them.

This organization of parties having been effected and the necessary arrangements made for breaking up the depot which had been established at this point the preceding season, the parties took the field in the following order: Lieutenant Carpenter's party on June 9, 1875; Lieutenant Morrison's, June 12, and my own on June 15, 1875.

The organization of the party under my immediate charge was as follows: First Lieut. W. L. Marshall, Corps of Engineers, executive officer and field-astronomer; Assistant Engineer J. C. Spiller, topographer; Mr. George M. Dunn, meteorological observer; First-class Private Wm. Looram, Company D, Battalion of Engineers, aneroid and odometer recorder; D. Y. Mears, chief packer; A. R. Mitchell and Harry Gregg, packers; Thomas Norman and Allen Smith, cooks, or in all nine men.

From Pueblo the party proceeded up the Arkansas River to Oil Creek, thence by way of the Twin Creek Pass to Tarryall Creek, where a small area left unsurveyed in 1873 by my party was filled out and the meander of Tarryall Creek continued until near the point it was left by Mr. Young's meander in 1873. Having completed this, the party

proceeded south of the Platte and Arkansas divide and completed the survey of about 250 square miles of the broken and rolling plateau lying in atlas-sheet 61*b*, between Cottonwood and Badger Creeks and south of Poncho Park, bordering the Arkansas Cañon. The road via the Currant Creek Pass was meandered until the old (1861) wagon-road from Cañon City to the Puncha Pass was reached, and this road then followed to the Arkansas River at the mouth of the South Arkansas, connecting with our meanders of 1874–'75 at this point.

From Puncha Pass the pack-train was sent to Saguache, and the topographer and myself proceeded to make stations upon Antoro Peak, a high mass south of the headwaters of Poncho Creek, and upon such other peaks along the continental backbone as were necessary to secure the drainage and detailed topography lying between the headwaters of the Tumichi and the northern tributaries of Saguache Creek.

We rejoined the main party at Saguache on July 10. On the 15th of July, having received the necessary supplies, we followed the southern fork of the Saguache, the tributaries of which were meandered to their heads, and, in addition, eleven triangulations and topographical stations were made by Mr. Spiller upon the high plateau surrounding the headwaters of Saguache and Lagarita Creeks, and dividing their waters from those of the Rio Grande and those sinking in the San Luis Valley north of Del Norte, after which the party crossed from the valley of the Saguache to the Cochetopa, striking this stream where the new Saguache and Lake City wagon-road crosses it. After meandering this road to the summit of the range, the main portion of the party was sent to Lake City, Mr. Dunn meandering the road from the agency to Lake City, while the topographer and myself, with a small party, turned to the southwest, and, attaining the continental water-shed, made two stations on high peaks, standing upon the volcanic plateau which forms the northern rim of the Rio Grande Loup; then proceeded westward, following the Cannibal Plateau, which forms the dividing ridge between the Lake Fork of the Gunnison and the Cebolla, to its northern terminus, and then, crossing the deep cañon of the Lake Fork of the Gunnison, attained the summit of the ridge culminating in the lofty Uncompahgre Peak on the west side of the Lake Fork, which, after making two stations, we left and went for supplies to the camp at Lake City August 3.

On the 5th day of August I left Lake City, and with a portion of the pack-train went to Antelope Park for rations which had been forwarded to that point, leaving the topographer to continue topographical work as directed by me. He made a triangulation-station upon the Uncompahgre Peak, re-occupying that station to perfect angles which had not been read a sufficient number of times the preceding season. Upon another peak, five miles farther east, meandered and profiled the road from Lake City to the head of the Lake Fork; made stations upon Red Cloud Peak, the highest of the Lake Fork group; upon Hanclie's Peak, a lofty mass at the head of the Lake Fork, and then followed the divide between the waters of the Lake Fork of the Gunnison and those of the Rio Grande del Norte, making frequent stations *en route* as far as to the point where the Lake City and Antelope Park trail crosses the continental divide, and returned to camp at Tellurium Post-Office, at the head of the Lake Fork, on the 15th of August, having made in twelve days three stations over 14,000 feet and six others approaching or exceeding 13,000 feet in altitude, besides the necessary meanders, profiles, and minor stations in an exceedingly rugged and difficult region.

On the 16th of August we proceeded via the Forks of the Animas and the incipient town of La Plata, here located, to the head of Hensen Creek, a tributary of the Lake Fork of the Gunnison, in which vicinity the topographer made several stations, to complete the topography of this region; after which we followed an old Indian trail to the valleys of the Uncompahgre and Unaweep, over a very high and rough country, the mountains breaking down very suddenly and the streams all flowing in excessively deep and rocky gorges. The great gorge of the Uncompahgre and that of Ibex Creek will equal or surpass in ruggedness of scenery and in depth any similar gorge in the United States. The descent into the valley of the Uncompahgre is very abrupt, rendering it improbable that this trail will be of any value, other than as furnishing horsemen a possible way of avoiding the Uncompahgre Cañon. From the head of Ibex Creek to the rim of the Uncompahgre Park, the trail is almost entirely above timber-line, and in the next three miles descends nearly five thousand feet to the park below.

After meandering the Uncompahgre to the northern boundary of atlas-sheet 61*c*, (38° 10′ latitude,) we entered the valley of the Unaweep, a tributary of the Uncompahgre. Two topographical stations were made on low hills in the Unaweep Valley, and a triangulation-station upon the most westerly of the range of rugged peaks which divides the headwaters of the Unaweep from those of the San Miguel, to extend our triangulation to the southwest; and then on August 26 crossed to the drainage-area of the San Miguel River, following the trail around the western extremities of the Unaweep group of peaks.

From our camp near the junction of the two forks of the San Miguel, where this river plunges into its deep cañon, Mr. Spiller with a small party crossed the cañon and made stations upon several of the nearly isolated points near the western border of

atlas-sheet 61c, while I meandered the Gold Fork of the San Miguel to its head and made a station upon the divide between this stream and the Uncompahgre. Returning to camp, a station was made by me at the forks of the San Miguel, and then I meandered the trail to the Trout Lake, near the head of the South Fork, where I was rejoined by Mr. Spiller, September 1. After making two stations upon high peaks in this vicinity, the party proceeded over the divide to the drainage-area of the Dolores, but on the 5th September it began to rain, and continued raining and snowing with but short intermissions until September 21. Advantage was taken of every intermission, and during this interval we succeeded in successfully making two stations in the divide between the Dolores River and Hermosa Creek, one of the tributaries of the Animas River, and in meandering the trails over the heads of the Dolores Cascade and Lime Creeks ; but the delay thus caused, coming upon us while in the midst of the area we desired to complete, caused us serious embarrassment and loss of time when it was too late in the season to regain it. Having completed the drainage of the upper tributaries of the Animas, the trail to Hermosa was meandered, and on September 22 the party started over to the Rio La Plata, which stream was afterward meandered to its head, and two topographical stations were made by Mr. Spiller and myself upon prominent peaks of the Sierra La Plata. The highest of the La Plata peaks, however, which had been selected for a principal station in the scheme of triangulation, was not accessible from the east, so that the party accordingly proceeded to the Rio Mancos, the western fork of which we meandered, and made a very successful station upon the La Plata Peak at its head.

Retracing our course, a topographical station was made upon the northern edge of the Mesa Verde, and upon minor points between the La Plata and Animas Rivers. On October 1 and 2, we crossed the low ridge between the Animas and Florida, and, after following the latter several miles to the northeast, crossed another low divide and entered the drainage-area of the Rio Los Pinos. The party was then divided, and the main party sent through the Los Pinos Cañon, which Mr. Spiller meandered; while I followed the trail about the heads of the western tributaries of the Piedra, along the divide between the Piedra and Los Pinos River, making the necessary topographical stations en route, and rejoined the party at the head of the Los Pinos Cañon. From this point the topographer and small party proceeded to make stations and secure topographical details about the headwaters of the western fork of the Rio Los Pinos, whence my party were driven by snow in 1874, while I went for supplies to Antelope Park, meandering en route the Rio Grande from the Ute Pass to San Juan City, and, in returning, profiled the wagon-road over the head of Crooked Creek as far as to the entrance to the pass; a topographical station was also made by me on a low peak on the western edge of Antelope Park.

Upon returning to camp at the head of the Los Pinos, October 9, I left directions for Mr. Spiller to complete the meanders of the tributaries of the Piedra, to make a triangulation-station upon the double-capped peak north of Pagosa Springs, and upon lower points in the Piedra basin, and then to cross over into the Rio Grande basin and proceed with its survey until rejoined by me. This programme was satisfactorily carried out by Mr. Spiller.

On October 10 I took one packer and a pack-mule, and, attaining the summit of the continental backbone at the head of the eastern fork of the Rio Los Pinos, followed the divide around the headwaters of the Piedra and the southern tributaries of the Rio Grande as far as to the headwaters of the Rio San Juan, making topographical stations upon ten of the highest peaks, including one five miles north of the Pagosa Peak, in the dividing range between the San Juan and Piedra, and Macomb's peak, named in honor of Col. J. N. Macomb, Corps of Engineers, who first explored the San Juan basin.

Under this peak heads the main or west fork of the San Juan, the east fork of the Piedra and Hot Spring and Thunder Creeks, tributary to the Rio Grande.

Although not of very great height, barely exceeding 13,000 feet, this is the culminating point of this portion of the Atlantic and Pacific divide, and a very marked and noteworthy feature of the landscape ; a long ridge of brown trachyte, surmounted by a cap of the same material, which is vertical on the south and west sides for many feet ; its summit is attained by climbing over the loose masses of trachyte which lie under very steep slopes on the eastern sides. This point was occupied in 1874, but snow and cold prevented any successful notes. A station was made the next day by Mr. Spiller, whom I met near Macomb's Peak, on a high point some miles northeast of Macomb, between the two forks of Hot Spring Creek.

From Antelope Park, beginning October 23, the topographer meandered and profiled the new wagon-road from Alden's Junction to Lake City, meandered Clear Creek and its tributaries, the road from Antelope Park to Del Norte, and the tributaries of the Rio Grande, which had not been completed last year, making en route the necessary three-point and topographical stations, to accurately locate the points adjacent to his lines and to check up his meander, while I made a station upon Bristol Head, taking repeated sights with 10-inch theodolites to our triangulation-stations, from which the

position of this point has been accurately determined; and then proceeded to the head of the west branch of the south fork of the Rio Grande and made a topographical station upon a high and sharp peak seven miles east of Mount Macomb. Snow had meanwhile fallen to the depth of from 10 inches to 1 foot upon the mountains, rendering mountain-work very disagreeable, and oftentimes dangerous, from slipping. On November 2, we were compelled thereby to bring our work in the high mountains to a close, after four and a half months of continuous and almost excessive labor in the high masses forming the Atlantic and Pacific divide and its outlying spurs.

From Del Norte the road via the Mosca Pass was meandered, the Huerfano traced to its mouth, and the Arkansas meandered thence to West Las Animas, where I disbanded the three parties of the Colorado section about the 25th day of November, 1875.

During the field-season the system prescribed by the printed instructions issued from the office of the survey in 1874 was carried out. Nineteen triangulation-stations were occupied by Mr. Spiller and myself, the principal of which were selected for their well-defined and sharp peaks as well as on account of their position in the scheme of triangles. The principal angles were repeated from six to twelve times. As soon as a peak was occupied, a substantial stone monument was built to a height of from 6 to 14 feet, and these monuments taken as targets thereafter. Prior, however, to the occupation of peaks, the natural object itself was taken as the target. In most cases, however, these points were very sharp and well-defined, so that monuments were scarcely necessary. The angles were read from a 6-inch Würdemann theodolite, graduated to read to 10 inches, the stations being from 15 to 60 miles apart. Where practicable the sides were near 30 miles in length, but in carrying the triangles across the wide stretches of mesa-country in the San Juan basin, where but few well-defined points were visible, long sights were necessary. Probably the largest triangle which has ever been measured falls in Colorado and New Mexico, viz:

La Plata Creek; Banded Peak; Mount Taylor.

	Miles.
From La Plata to Banded it is	83.905
From Banded to Mount Taylor	139.876
From La Plata Peak to Mount Taylor	154.499

From Gray's Peak, near Denver, to Mount Taylor, the azimuth is carried by four lines of sight:

	Miles.
1. Gray's Peak to Hunt's Peak	86.250
2. Hunt's to Uncompahgre	71.515
3. Uncompahgre to La Plata Peak	55.200
4. La Plata to Mount Taylor	154.499
Total	367.464

Also,

	Miles.
1. Gray's Peak to Pike's Peak	65.614
2. Pike's to Sierra Blanca	90.338
3. Sierra Blanca to Banded	70.791
4. Banded to Mount Taylor	139.876
Total	366.619

The first line of sights was carried by my parties, Mr. Nell and Mr. Spiller measuring the angles, from Gray's Peak to Mount Taylor; the second, as far as to the Sierra Blanca. Banded Peak was occupied by Lieutenant Morrison's party in 1875 and Mount Taylor by Lieutenant Price's party in 1874, and re-occupied the past season by Lieutenant Morrison's party, the angles being read by Messrs. Thompson and Clarke. Sierra Blanca was re-occupied 1875 by Mr. Maxson, of Lieutenant Carpenter's party.

In addition to the triangulation-stations, which have all been computed, seventy-seven high peaks were occupied as topographical and secondary triangulation-stations. Upon these the angles were read to the nearest minute, repeated to primary stations to give sufficient reliable data for the computation of the position of the more important of these points. Seventy-four lower points were also occupied, which were mathematically fixed, and numerous check-stations introduced upon the meander-lines. Upon each triangulation and topographical station a panoramic view of the horizon was made in perspective and sights taken to all points not too distant, such as peaks, ends of marked spurs, junction-courses, and bends of streams, towns, ranches, and other artificial features; and these points accurately located in relative horizontal position by intersections, and vertically by angles of elevation or depression. In the immediate neighborhood of the stations horizontal plans showing the local topographical details

were made. Since a large tract of country was covered by the party, the topographical stations were made on an average of one every seven miles. Points located by intersections from these stations or computed from the measured angles in connection with the bases measured in 1874 are taken as the frame-work or skeleton for the map now being constructed by Mr. Spiller; and the minor details, roads, streams, &c., filled in from meander-lines and sketches and bearings made along the trails; the distances being measured by odometer, checked by frequent three-point stations, and the bearings from a topographer's transit. Each of the meander-stations, which numbered about seventeen hundred, was also a barometric station, so that continuous profiles are secured over the entire route of the party.

The method of covering large areas by sketches alone from high stations, these stations made on an average of from 8 to 12 miles apart, is defective—

1st. Because it can only be applied in a mountainous country, where well-defined points exist which may serve as vertices for the triangles and for commanding positions from which the necessary sketches may be made; at best, then, it is only applicable to limited areas.

2d. Except in very exceptional districts not more than one-half the points sighted from one station can be recognized or seen from another; particularly is this true of the lower points sighted.

3d. The details are good only in the immediate neighborhood of the points occupied, *i. e.*, in the most inaccessible and practically the least important portions of the territory to be mapped. Any one at all cognizant with mathematical drawing can at once understand the difficulty and the absurdity of attempting to represent the details included in from 49 to 144 square miles of territory from sketches and bearings made from a single station; of representing properly the sinuosities of roads and streams from occasional sights at prominent changes of direction, &c., and of representing by accurate contours the slopes of the country from such data as can be obtained from so few primary barometric bases, upon such a large scale as required for detailed topographical maps.

In a partially mountainous region, watered by numerous streams, traversed by roads, and quite well settled, as parts of New Mexico and Arizona, where peaks above timber-line are rare, and well-marked points are not very numerous, the method would prove a failure as far as detailed maps are concerned, for, in addition to the objections to the system where commanding points can be obtained, the foundation of the system itself would be insufficient for its requirements, where such stations do not exist. In level districts or on the rolling plains it is worthless.

The mountain-stations are, as they have always been used on this survey, essential to a good map; they are necessary for securing the mathematical accuracy needed in the location of points; for gaining a knowledge of the headwaters and upper drainage of minor streams which cannot be meandered, and for impressing upon the topographer's mind a good *general* idea of the topography and the relations of great topographical features to each other; but to rely upon the knowledge gained from them for an accurate *detailed* map of the artificial as well as the natural features of the country is folly, reasoning as topographical features and stations *are* and *must be*, and not theoretically as they *should* be, found.

As previously stated, the high stations were made during the past season as numerous as have ever been practiced by the advocates of this method, and its insufficiency showing itself in the lack of practical details in the lower and inhabited and traveled regions, close odometric meanders of all the roads and principal streams and careful profiles were made for furnishing the information absolutely necessary for the work, and which could not possibly, without immense physical labor and expenditure of time and money, be secured from topographical stations.

The odometer, if checked by the three-point problem every 8 or 10 miles, will give results which will compare very favorably with actual chaining, at a great gain of time and expense, and the bases measured by it serve well for the location of all points within a few miles of the trails followed, and which may not be better located from triangulation or topographical stations. Some form of this instrument must necessarily always form part of the outfit of a party engaged upon geographical work in unsettled regions, its importance increasing with the number of marked topographical stations decreased. In nearly every portion of the West, however, which still remains to be mapped, there is always to be found a sufficient number of marked natural objects to serve as vertices for a system of triangles, which may be located easily and at not too great expense, to be used as checks upon odometer-meanders to prevent the accumulation of errors by false measurements.

Where the camps could not be located trigonometrically, latitude-checks were introduced by me; but these were seldom necessary in the mountainous region traversed by the party the past season.

BAROMETRIC WORK.

Cistern-barometers and thermometers were used at the hours prescribed by the printed instructions, in camps and on the march, at culminating points of the trails.

Aneroid-barometers and thermometers were observed at all meander-stations; the aneroid being compared with the standard every morning and evening, and, when a considerable elevation was crossed, at its summit also. When stations were made upon peaks, simultaneous observations were taken at base and summit on cistern-barometers and psychrometers. General meteorological observations were also taken.

Profiles of all routes by which the San Juan mines can be reached were taken, and will be found appended to my descriptive report of routes of communication.

I wish here to tender my acknowledgments to Mr. J. C. Spiller and Mr. G. M. Dunn, for the care and pains taken to perfect their notes and secure abundant and good material in their several branches of work. The former gentleman brought from the field very full and elaborate sketches and topographical details, and the records of the latter were kept throughout the season in good shape. Mr. Dunn also succeeded in transporting his barometer throughout the season and bringing it back to the office without injury, which is quite a success, considering the rough character of the country surveyed and the means of preserving the instrument from almost inevitable falls and consequent injury.

Part II.—General description of the area surveyed.

The Platte and Arkansas divide, or that portion of it surveyed this year between the southern edge of South Park and the Arkansas River, is a high rolling area, covered along its northern surface with basaltic and trachytic overflows, with but few high peaks and but scantily timbered. Ridges and low cones of lava appear here and there above the general level to the north, heavily grassed with the nutritious bunch-grasses of the mountains, and quite well watered by tortuous streams. A portion of the divide reaching from near the head of Currant Creek to Basalt Peak—a black mass sloping like an inclined plane to the west, but abrupt on other faces—rises to over 11,000 feet above the sea. Between Basalt Peak and Trout Creek Pass, however, the elevation is slightly above the general level of South Park. Over this portion of this high rolling area are scattered many little parks and grassy swales, the most extensive of which is Puncha Park, south of Basalt Peak, and the basin at the head of Badger Creek. Several cattle-ranches are located in these beautiful little parks, the cattle running at liberty over the hills during the summer-months, but are driven to lower altitudes for winter-herding. The streams bordering on the south side of the divide or those flowing into the Arkansas cut quite deep cañons in the plateau, attaining the level of the Arkansas from 2,000 to 3,000 feet below the summit of the limiting rim of the cañon of that stream. The general level of that portion of the plateau south of Basalt Peak exceeds that of the northern portion. South of Puncha Park is a short range of peaks rising nearly to timber-line, or to about 11,500 feet, which furnish water to Tallahassee, Gorell, and Badger Creeks. The basin of Badger Creek, save toward the north, is inclosed in quite well-defined ridges, and its cañon for miles above its mouth is a very formidable one. Stratified rocks appear, in quite extensive development in this southern portion of the Arkansas plateau, and predominate over the trachytic overflows. There is no agricultural land, except narrow strips along the cañons of Current, Tallahassee, and Gorell Creeks, the general level exceeding 9,000 feet above the sea.

The scarcity of timber, save upon the high ridge between Basalt Peak and 39-Mile Mountain and the ridge bordering Badger Creek, is quite a marked feature of the Arkansas plateau. The southern slopes of the hills are well grassed, but there are very few trees; these occur, where at all, on the northern slopes. This is probably due to the pervious nature of the trachytic soil and the greater dryness of the southern slopes. Spruce is the principal timber, but this gives place, near the Arkansas, to juniper and piñon. The old (1861) Puncha Pass and Cañon City toll-road leaves Currant Creek near the Soda Spring, and passes through Puncha Park, and via the headwaters of Badger Creek, to the Arkansas River, near the mouth of the South Arkansas. It is now abandoned, the more southerly route, via the Arkansas Cañon and Pleasant Valley, being now used as the mail-route. It is easy, however, to travel in nearly any direction over the divide, save near the Arkansas River, where it is too much cut by cañons. The country bordering the Arkansas River has been already well described by Professor Stevenson in his report; it is barely sufficient to say that at the mouth of the South Arkansas the valley of the Upper Arkansas, which lies between the massive Saguache range and the edge of the Arkansas plateau, and extends for some twenty miles above the point named, is closed by the foot-hills of the Sangre de Cristo range, through which the Arkansas has cut a short but narrow cañon. This valley is not of great importance; the agricultural lands are limited by the edges of terraces, which, breaking down in succession from the slopes of the high peaks to the west, close in within a comparatively short distance of the river, and by their height, and by the fact that they are cut transversly by the cañons of the streams emerging from the mountains far below the level of their upper surfaces, irrigation of any considerable proportion of this valley, at reasonable expense, is precluded.

Several ranches, however, exist, and fair crops are raised. On the South Arkan-

sas itself are many little farms, and the climate is quite mild, as is evidenced by the number of cacti and other southern plants which abound over the surface of the valley. Grass is very scant, and as a grazing region it is insignificant. The scenery of this portion of atlas-sheet 61*b* is unsurpassed. The wide valley of the Arkansas, with the Saguache range rising abruptly from its western terraces to over 14,000 feet altitude, massive and snow-crowned; the Sangre de Cristo range, as a spur shooting off from the Saguache range at Hunt's Peak, (a lofty, sharp point south of the South Arkansas River,) trending around to the southeast and closing the valley; the Arkansas plateau to the east, with its almost uniform surface, and to the north the rounded humps of Buffalo Peak, offer to the view the greatest variety of landscape and the gentlest as well as the most imposing of natural features. Some 6 miles above the mouth of the South Arkansas this stream is joined by Puncha Creek, which is notable as offering the only practicable pass into the San Luis Valley from the east, between its head and the sand-hills, 60 miles distant. The approaches to the pass from the Arkansas Valley are narrow and quite tortuous, the road crossing and recrossing the stream at frequent intervals, but the grades as established are quite uniform and a very good wagon-road exists. The ascent averages 250 feet to the mile; hence it is too steep for railroad purposes. Over the head of Puncha Creek, between Hunt's Peak and Mount Antoro, the last high peaks of the Saguache range, it is practicable to build a road to the west for wagons, and, now that the valley of the Gunnison is being rapidly filled with settlers, it will be an obvious advantage to build one at this point. The ascending gradient is about the same as in the Puncha Pass from the South Arkansas, but on the west side there is a steep pitch from the summit, which, however, may be avoided by carrying the road around the hill-sides, lengthening the road, and thereby diminishing the gradient. Upon the western side in a few miles from the summit the country opens out into the Tumichi Valley with very gentle slopes. It may also be practicable to build a road over some of the headwaters of the South Arkansas. The range runs no lower down, but it is much wider in that vicinity, and there would be consequently a larger stretch of mountain-road even if practicable gradients can be secured, which is not yet ascertained. Capt. J. W. Gunnison, in vol.— of the Pacific Railroad Surveys, remarked upon the apparent existence of passes at the heads of the Tumichi and Carnero Creeks, which led me more closely to examine this vicinity than perhaps I should otherwise have done.

The summit of the Puncha Pass, 8,945 feet, being attained, one finds himself at once in the San Luis Valley proper, the Homan's Park of Gunnison. It is very narrow in this vicinity, being inclosed by the northern extremity of the Sangre de Cristo range and the broken volcanic overflow which covers the region about the headwaters of Kerber Creek. Gradually widening out toward the south, it attains at its maximum a width of some forty-five miles at Del Norte and ends about the southern border of Colorado, where overflows of volcanic matter break the general level. On the eastern side it is bounded by the Sangre de Cristo range, a very decided and well-marked sierra gradually rising toward the south from 9,000 feet at the Puncha Pass to 14,300 feet at the Sierra Blanca. Many of its sharp peaks attain 13,000 feet, and several, notably the ragged mass called the Three Tetons, exceed 14,000. The continuity of the range is unbroken and, though narrow, (barely twelve miles from the San Luis Valley to the Wet Mountain Valley on the eastern side,) is, on account of the steepness of its slopes and the ragged nature of its crest, impassable, save at the depressions called the Hayden, Music, Sand-Hill, and Mosca Passes. Of these the Mosca Pass is probably the only one which will be used in ordinary travel and traffic. The Hayden and Music are too steep, and on the eastern side the approaches to the Sand-Hill Pass are bad and on the west it is choked with sand. On the San Luis Valley side the Sangre de Cristo range is very abrupt, shooting up at once from the plain; from the east, however, its summit is very much more easily attained. Long slopes extend from near timber-line far into the Wet Mountain Valley, which is itself considerably higher than the San Luis. Wet Mountain Valley indeed resembles more a slightly-hollowed-out glacial bench upon the flanks of the Sangre de Cristo, than a true valley of depression between the Sangre de Cristo and Wet Mountain ranges.

At the Sierra Blanca, the most massive and imposing group in Colorado Territory as far as I have observed, which rises nearly 7,000 feet above its base, the Sangre de Cristo range ends; more properly or orographically speaking, it ends at the Mosca Pass; and the Sierra Blanca should be perhaps named as a separate division of the Rocky Mountain system, beginning at the Sangre de Cristo Pass and ending at the Mosca.

From the Sierra Blanca the bounding ridge of the San Luis Valley changes its direction to the eastward, and, after encircling the heads of the Sangre de Cristo Creek, continues its course to the west of south. South of the Sangre de Cristo Pass the range changes its character from the sharp sierra of the Sangre de Cristo proper, and is now a mountain-range, with more massive and rounded peaks and longer foot-hills and slopes. Its high and impassable character is preserved, however, and no passes worthy of the name exist south of the Abeyta until the Taos Pass in New Mexico is reached. These passes fall within the a ea surveyed by other parties of the expedition, and ref-

erence is made to their reports for description. It is, however, to be remarked that, since the southern continuation of the Sangre de Cristo range holds snow throughout the year, and its summits and slopes are less steep and consequently averaging more high land, and therefore less affected by the heated air of the San Luis Valley and the plains to the eastward, and less rapidly drained also, the streams which flow down their slopes are more constant, and, instead of soon sinking in the sand and volcanic *débris* of the valley, reach the Rio Grande on the surface.

The character of the bounding ridge west of the San Luis Valley is altogether different from that just described. Although a component part of the Atlantic and Pacific divide, the part facing and bounding the San Luis Valley is not imposing from its great height, and is remarkable only for the lack of marked points.

Due west of the Puncha Pass, the massive and peaked Saguache range ends at Mount Antoro, a rounded trachytic mass about 13,450 feet in height. The divide from this point trends to the westward, with rounded, wooded hills, for some 15 miles, and then turns to the southwest around the heads of the Saguache for 40 miles; then, making the remarkable tongue-like loup about the headwaters of the Rio Grande, again continues its course to the southwest, on the western border of San Luis Valley, below Del Norte.

That portion of this divide seen from the San Luis Valley is an extensive trachytic overflow, of a plateau rather than a mountain character, cut by streams which flow in cañons of greater or less width, sometimes inclosing within their walls beautiful little valleys and parks, heavily grassed and well wooded, at other points narrow and gorge-like impassable box cañons, its summit covered here with piñons, there by groves of pines, spruce, and quaking-aspen, and again by long, sweeping, rolling stretches, bounded perhaps by vertical ledges of trap, but beautifully and luxuriantly grassed, affording now shelter and pasturage for numerous deer and few elk, and in future destined to be, like the Arkansas plateau, the summer range of more domestic cattle.

The few mountains deserving the name in this portion of the San Luis Valley rim are rounded, wooded, dome-like masses, seldom rising above timber-line, save near the heads of La Garita and Carnero, where they attain considerable height. That portion of this overflow between the headwaters of the Saguache and the San Luis Valley is cut up by the drainage-lines and cañons of the streams into numerous little hills and limited benches, which, though presenting from the valley the gently-sloping and sweeping outlines characteristic of such formations, offer serious difficulties to travel by frequent almost vertical bluffs and many ascents and descents along any given line.

The streams rising in this broken plateau north of the Rio Grande and flowing into the San Luis Valley sink in the sand or swell the volume of the San Luis swamp. South of Del Norte, the Conejos and Alamosa, which rise far back in the Sierra San Juan, invisible from the valley, reach the Rio Grande on the surface; others, as the Piedra Pintada and La Jara and Rito San Francisco, sink in the gravel.

From the head of the San Luis Valley, looking south, the view is similar to what is seen in the dryer valleys of the great basin; the Sangre de Cristo range upon the eastern border; the broad expanse of plain, with the rounded summits of the Cerro de las Utas and the Cerro San Antonio just appearing above the horizon or lifted by the mirage, together with the flat-topped and limited basaltic mesas between them, far into the air; the cerritos, or little hills of lava, about the gate-way of the Rio Grande at Del Norte quivering through the vibrating air; the glaring white sand-hills, with their wavy crests and outlines piled in front of the Mosca Pass, all suggest the Great Basin rather than the region of the Rocky Mountains.

The surface of the San Luis Valley is very interesting and quite varied in its characteristics. In the northern end, San Luis Creek, and Kerber Creek, its tributary, and Saguache Creek, a large mountain-stream, flow out into the center, and, here uniting and spreading out over the flat surface, give rise to the San Luis swamp. It is a swamp, properly speaking, only for 8 or 10 miles; but there is a succession of pools and small lakes of slightly alkaline water and covered with myriads of water-fowl near the eastern edge of the valley, from about 5 miles below Saguache, and in certain seasons from Saguache as far as to the mouth of the Mosca Pass. In the northern portion of the area covered by this swamp, where quite extensive tracts are kept constantly wet, there is a most luxuriant growth of swamp-grass and sedges. White-tail deer abound, and large herds of cattle find sustenance in these sedges and grasses. These are cut quite extensively for hay, and are said to be valuable for that purpose. Certainly some use other than is now made of this abundant material will be found. The cattle seem hardly to make an impression upon it; it grows to the height of a man's waist, is very thick and heavy upon the ground, and covers a large area. From the commencement of the swamp far up into the cañon of the Saguache, or for about 20 miles of its course, it is bordered by the richest of soils, producing most abundant crops of wheat, oats, and vegetables, and is by far the most inviting agricultural region of the valley. In the cañon of Saguache, the bottom-lands, as far as the bend of this stream, easily irrigated at slight expense, will average one-fourth of a mile in

width, capable of cultivation for 12 or 15 miles above Saguache, and above that point furnishing, in connection with the bunch-grasses of the rolling and plateau-like region bordering it, abundant grass for stock nearly to its head. The streams, other than those named above, tributary to the San Luis swamp, but which reach the center of the valley under the surface, are bordered by but narrow strips of agricultural lands and furnish but little water for irrigation. The intervals between the streams in this portion of the valley are almost destitute of vegetation other than sage and chico, of which there is quite an abundant growth. About midway of the length of the valley, the Rio Grande emerges from the mountains to the west, and, after following its course to the south of east for 30 miles, turns to the southward, and soon enters a cañon with low walls of volcanic material. It is joined by the Trinchera, Culebra, and Costilla Creeks from the east, and by the Conejos and Alamosa from the western side. These are all quite large streams, and along their banks are quite extensive strips of land, not difficult of irrigation, and of good soil. This is particularly true of the Conejos, which is quite thickly settled along its banks by Mexicans; and the Upper Culebra, where a quite extensive and fertile valley, watered by numerous little streams tributary to it, is cultivated. Beyond the strips of agricultural land bordering the streams, the southern portion of the San Luis Valley is now a desert. The soil is decomposed trachytes, resembling in texture gravel and coarse sand. There are extensive areas, covered originally not very thickly with short grass, where large herds of sheep are herded by the Mexican inhabitants and keep the face of the earth bare wherever they are driven.

Undeniably the greater part of this soil is capable of producing good crops, its fertility being apparent in the luxuriant growth of sage and greasewood, which in great part covers it.

Indeed, the San Luis Valley, if its resources of water were utilized to the full requirements of the land susceptible of irrigation, is capable of sustaining any population the extensive mines of Colorado in its vicinity are likely to attract. In the southern portion good crops of corn and vegetables are produced and in the northern the usual small grains. The marshy and arid portions of the valley are capable of furnishing the necessary flesh-food. Agriculture, however, at present is not profitable, and the people who have settled it are mainly stock and wool growers. The present state of agriculture cannot, therefore, be taken as at all representative of the capabilities of this valley.

The entire valley is treeless, save along a few of the larger streams, where groves of cottonwood exist. On the northern and western rims, near the valley, piñon, a fine fuel, is abundant, and farther back spruces and pines for timber. The Sangre de Cristo range from the edge of the valley to the timber-line, wherever the slopes are sufficiently gentle to retain soil, are well wooded with spruce and cottonwood; the latter, however, of small size, fit only for poles and fencing.

This large area, comprising over 2,000 square miles, is but thinly settled, compared with its resources; but the richness of the mines in its vicinity and the consequent demand for its products is causing quite an influx of population.

Saguache and Del Norte are quite prosperous towns, and the agricultural lands, especially about the former, are nearly all taken up by settlers.

With the exception of the Americans at the two towns mentioned, the United States troops at Fort Garland, and a few rancheros in the valley, the population is Mexican, and is mainly distributed about numerous small plazas on the Conejos, Culebra, and Costilla Creeks, where they live in poverty, ignorance, and idleness; dwelling in wooden stockade-like pens plastered with mud, or in more or less pretentious huts of adobe, cultivating the ground even yet in primitive fashion with wooden plows, drawn by oxen, and raising barely sufficient crops of corn, oats, onions, and chili or red pepper for their support, their poor sheep and the jack-rabbits of the sage-fields furnishing their meat.

From the time we left the San Luis Valley, in July, until the first part of November, the party were almost constantly in the mountains surrounding the headwaters of the Rio Grande. A minute description of our work and daily travels, and of the local peculiarities of the small areas examined daily by us, would perhaps give a very vivid idea of the personal toils and trials of the party in mountain-travel, but would perplex the mind with unimportant details, and prevent its comprehending the general topographical structure of this interesting region. For this reason I will continue a general description, referring to particular features only where they are remarkable and specially noteworthy.

A little to the north of Saguache the Cochetopa Pass (first examined and reported upon by Capt. J. W. Gunnison, United States Topographical Engineers, in 1853) offers the most practicable passage-way from the Atlantic to the Pacific slope along the Rocky Mountain barrier from Cheyenne to New Mexico. South of this pass the divide sweeps round to the west, and then, at about 107° 35′, returns upon itself, inclosing in a wide and deep tongue-shaped *cul-de-sac* the headwaters of the Rio Grande del Norte. The

portion of the divide forming this *cul-de-sac*, with its slopes, may be subdivided for the sake of description into three divisions:

1st. The northern, extending from the Cochetopa Pass to the depression at the head of the western tributary of the Cebolla Creek.

2d. The bottom of the Loup, extending from this depression to the pass at the head of the Rio los Pinos; and

3d. From the headwaters of the Los Pinos to the Sierra San Juan and the Summit mining-district southwest of Del Norte.

About the bottom of the Loup are numerous short ranges, determined by the gorges and cañons of the streams flowing from them, which, for convenience and because they are connected intimately with this portion of the divide, will be described in full with it.

The first and third of these divisions are similar, inasmuch as they exhibit more clearly the plateau character of the volcanic overflow reft by the cañon of the Upper Rio Grande, and cut out by water and ice into cañons and gorges, until now portions of the plateau exhibit mountain-peaks and short ranges. This first division, however, more distinctly retains its plateau-like character. Beginning at the Cochetopa Pass, the summit of the divide gradually increases its height from 10,000 feet at the pass to approximately 13,600 feet at the head of the Saguache, exhibiting the character already described in speaking of the western rim of the San Luis Valley. The east branch of the Saguache heads in tremendous cup-like cavities and box-canons under mesa-like portions of this plateau, which here may be followed for miles around the headwaters of the Saguache, La Garita, Carnero, and Embargo Creeks, upon nearly a flat surface, strewn with trachytic rocks, and covered, where decomposition of these rocks has sufficiently taken place to furnish a soil, with a thick mat of Alpine grasses and flowers.

Upon the Rio Grande side the descent from the head of the Saguache to the river, a few miles distant, is very abrupt; here vertical ledges and bluffs close in upon the river and form the narrow and short cañon called Wagon-wheel Gap, 30 miles above Del Norte. From the heads of La Garita and Embargo Creeks, where the flat mesa-like surface ends, eastward to the San Luis Valley and southward to the Rio Grande, the country breaks down in detached hills and bluffs, and near the valleys sharp points or cerritos of basalt.

West of the deep crateriform cavity, in which heads the eastern of the two main branches of the Saguache, the plateau is crowned by a short ridge of volcanic material, curving sharply down to the surface of the grassy plateau in steep slopes of loose fragments to the south, and inclosing in perpendicular walls, in semicircular sweep to the north, the headwaters of the main or western branch of the Saguache. These peaks surmount the plateau for some 12 miles farther west, several of them approaching 14,000 feet in altitude, and end in conical masses which slope gradually down to the upper surface of Bristol Head, a plateau-mountain V-shaped in plan, the opening of the V turned to the north and the vertex near the Rio Grande. This mass is of, perhaps, 30 square miles' area, bounded by a vertical bluff from 2,500 to 3,000 feet on the southwestern side of the V, and by slopes more or less gradual or abrupt on the eastern. It is nearly 13,000 feet in altitude, and a marked feature of the landscape. It is composed mainly of a brownish trachyte.

The country to the north of these peaks slopes down to the Gunnison, the slopes being cut by the cañons of the Cochetopa and Cebolla and their tributaries into subordinate ridges of not great height, and even crest.

West of the Bristol Plateau and the peaks standing upon it as a pedestal, there is a depression extending some eight or ten miles about the heads of western forks of the Cebolla, a great part of which is below timber-line. Being rather imperfectly drained, it is covered by numerous marshy spots. From the lowest part of this depression, over which the Indian trail from the old Los Pinos agency crosses into the Rio Grande Basin, the country—a rolling series of hills well grassed—slopes gradually upward to the rim of the Clear Creek Basin, which also forms the western wall of the cañon of the Lake Fork of the Gunnison. A break in this latter rim at the headwaters of the western branch of the Cebolla offers a passage-way for the new wagon-road, which leaving the valley of the Rio Grande under Bristol Head, first crosses the Atlantic and Pacific divide to this branch of the Cebolla, which it follows to its head and over the break mentioned to the cañon of the Lake Fork. North from this breaks a round-topped, rolling stretch of elevated country, ranging in altitude above sea-level from 12,000 to 12,800 feet, and named by us the Cannibal Plateau—in memory of the horrible butchery and acts of cannibalism which were practiced under its western edge in 1874—extending for about twelve miles, through the eastern slopes of which the Cebolla, which has first collected the numerous branches flowing down from the mountains north of Bristol Head, cuts a formidable cañon.

From a few miles south of the Cochetopa Pass, around this northern rim of the Rio Grande Loup to the depression northeast of Bristol Head, or for the entire portion of this rim in the first of the divisions into which this loup is divided, the range is impassable, transversely, for other means of transportation than lightly-laden pack-mules, and for those in but very few places.

In the valleys of the Cochetopa and the Upper Saguache, above the walls of its cañon, and on the rolling hills southwest of the Cochetopa Pass, is much fine grazing-land, which, however, is too high for winter herding. The same may be said of the valley of Cebolla, above its cañon. All of the streams flowing from this portion of the loup to the northward, cañon up a short distance from their heads, so that in the upper portions of their courses there is but little bottom-land. This is at too great an altitude for cultivation.

Below the cañon of the Cebolla, however, there are several ranches where potatoes and the hardier cereals were cultivated, but whether they would mature cannot be said, since it was an experiment being tried when we passed. Timber and fire-wood are abundant. No mines have as yet been discovered in this division, and beyond a few ranches along the Lake City and Saguache road, there are no inhabitants on the northern slopes of the range.

2.—THE BOTTOM OF THE RIO GRANDE LOUP AND THE NEIGHBORING RANGES AND MASSES.

This division of the continental backbone, with its spurs and attendant ranges and mountain masses, is the most interesting of the mountainous portion of Colorado, both on account of the high and rugged character of its mountains, and the great area covered by their peaks, and the number and character and prospective value of the mines here discovered and now being rapidly developed. Of the mines but little will be said, since the character of the work precluded any investigation of the subject from want of time. The examination of a single mine, including the time necessary to reach it, would occupy an entire day, and since but little over a month could be given to the survey of the entire complicated mass of mountains in which they are situated, this time could not be spared for each of the many mines which would have to be visited; besides, they are only partially developed, and not much can be said as to the persistency and value of the lodes discovered, whatever may be their prospects. The topography of the country and the engineering questions relating to the routes of communication, and those relating to the capacity of the regions in the neighborhood of the mines to subsist a large population, were the subjects which more particularly engaged the attention of the party, and it is of these that we will principally speak.

West from Bristol Head the country slopes up from the valley of Clear Creek to the summit of the rounded peaks which border the cañon of the Lake Fork of the Gunnison by not abrupt gradations. Clear Creek heads not far from the Rio Grande, and runs a little north of east from its head under a rounded mass near the head of Crooked Creek, for some 8 miles of its course bordered by a grassy though narrow valley. Numerous tributaries enter it through cañons from the rounded mountains to the northwest.

Between Clear Creek and the Rio Grande is an area of some 50 square miles, with nearly level upper surface, cut by the valleys, or rather cañons, of the tributaries of Crooked Creek. This bench is about 9,600 to 10,200 feet in altitude, and ends at the base of the rounded mountain just referred to. Along the southern edge of this bench the Rio Grande runs in a cañon bounded by walls 1,200 to 2,000 feet in height on the southern side, but only 800 to 1,000 on the northern. The rounded summit under which Clear Creek heads, divides it from Lost Trail Creek, which with Pole Creek runs down from the edge of the Lake Fork Cañon, which here becomes more mountainous and peaked in its general appearance; the divide increases in height and in ruggedness, from the heads of Clear Creek, inclosing, besides Pole and Lost Trail Creeks tributary to the Rio Grande, numerous short tributaries of the Lake Fork of the Gunnison in its northern ravines. Toward the south, however, it retains its high altitude for several miles, or until near the narrow valley of the Rio Grande, to which level it breaks down abruptly by bluffs. On the Lake Fork side the fall from the divide to the level of the stream is very marked and abrupt. The rim is strongly marked and linear, parallel to the stream, with ravines running down its steep slopes.

Near the head of Pole Creek a branch of the Lake Fork, named by Mr. Prout, Snare Creek, takes its rise. Between this stream and the headwaters of the Lake Fork and the Animas is a group of four peaks, exceeding 14,000 feet altitude, of which Handies Peak is the culminating mass. South of this group there are no high peaks in the divide, but there is quite a broad plateau bordering the eastern side of the Animas and separating it from the heads of Pole Creek, which extends to Mount Canby, an irregular red mass of volcanic material near the headwaters of the Rio Grande.

About the immediate head of the Rio Grande itself, the country is an extensive area above timber-line, exhibiting no marked peaks of height above the general surface on the western side; but to the south, and in fact in every direction, save to the east, towering peaks, high above timber, and with bold sky-lines and profiles, can be seen, but these are in subordinate groups and not in the main divide itself. On the southern side of this semicircular division, about the heads of Hines Fork and Ute Creek, are peaks reaching 13,500 feet.

Between Hines' Fork and the Los Pinos Pass are very well-marked and steep spurs, with well-defined peaks, and slopes broken by bluffs of trap. On the western side of Ute Creek the spur between this stream and the Los Pinos Pass is of nearly uniform height, save that near its center, rising from its upper surface, as from a suitable pedestal, is one of the handsomest and most symmetrical cones in Colorado. It is about 5 miles from the Rio Grande River, and is a marked feature, noticeable and prominent from every point of view, the more so, perhaps, because there are so few peaks in its immediate vicinity, the other mountains in the same spur having rounded summits, or apices, with very gently-sloping upper surfaces; the lower slopes are bluff-like. This cone was ascended by my party in 1874, and a primary triangulation-station made upon it. It was named by me Simpson's Pyramid.

On its eastern side the Rio los Pinos takes its rise and flows south through a tremendous cañon toward the San Juan. East of Simpson's Pyramid the Ute trail crosses from the valley of the Rio Grande to the head of the Rio los Pinos; its summit is flat and marshy for some miles, or until the fall of the Los Pinos is sufficient to give good drainage. The descent to the Rio Grande side is exceedingly steep for about half a mile, the fall in this distance being 1,000 feet. The pass will never be valuable as a wagon-route unless the discovery of very rich mines about the headwaters of the Los Pinos makes it a necessity.

The minor streams in this division all have rapid fall, and, except Hines' Fork, near their mouth flow through narrow cañons. Their headwaters, however, as a rule, are in Alpine meadows with not excessive slopes; covered, however, with a thick growth of mountain-willow, which much impedes travel. In places, also, the surface of these more gradual but limited slopes is broken by short ledges of trap, from 4 to 50 feet in height, which readily puts an end to mule transportation or causes a very winding course to be followed.

As seen from the Rio Grande Cañon, however, the characteristic of this division is abruptness, and indeed all the streams save Clear Creek are bordered by lofty escarpments and steep slopes.

Although on the Rio Grande side of this division as far as to the summit of the divide, there are, with the exception of Simpson's Pyramid, no very remarkable topographical features, upon the Pacific slope are numerous sharp ranges and spurs of gigantic mountains, peaked, cut by deep cañons and frightful gorges, rising far above the limit of arborescent vegetation, covered the greater part of the year with snow, the locus now of one of the most extensive and rapidly developing mining regions in the United States.

These ranges and spurs are:

1st. The Lake Fork group of peaks.

2d. The Uncompahgre Peak group.

3d. The Unaweep range.

4th. The Sierra San Miguel.

5th. The "Needles," Floridas Comb, or "Sierra Los Pinos" of Newberry, about the heads of the Rio los Pinos, and the masses of mountains within which heads the Animas River.

In these groups of high and rugged mountains, which cover approximatively with their peaks the area between longitudes 107° 20′ and 108°, latitude 37° 35′ and 38° 08′, or about 1,400 square miles, the Animas, Rio los Pinos, and Rita Florida, tributary to the Rio San Juan, the Dolores, San Miguel, Uncompahgre, and Lake Fork of the Gunnison, and other minor streams tributary to the Gunnison, and the Rio Grande del Norte with its headwaters intertwined with the above, take their rise. Perhaps within the limits of the United States there cannot be found another area of the same superficies so intricate in topographical detail, so rugged and steep and difficult of access, and requiring so much patience, energy, and hard physical labor in its survey.

In the center of this mountain region the Animas River takes its rise and drains with its tributaries Cement and Mineral Creeks, an approximatively elliptical area with the longer axis northeast and southwest, or from the head of the Animas to the head of the south fork of Mineral Creek. The Animas River itself runs parallel to the eastern portion of the periphery of this ellipse, bending around from its headwaters, first to the south, then southwest, closely bordering the bounding elliptical divide, and finally cuts through this rim in a tremendous cañon some 15 or 16 miles in length, and from 2,500 to 4,000 feet in depth. The southwestern vertex is drained by the south fork of Mineral Creek, while the north fork of this stream drains the western portion of the periphery. Cement Creek, lying between the Animas and the north fork of Mineral Creek, drains but a very small portion of the periphery, and is a comparatively insignificant stream. The larger axis of this ellipse is 20 miles, the shorter about 14 miles in length.

Following the divide around from the head of the Animas, we have the Lake Fork of the Gunnison heading near the northeastern vertex. It flows first in a south-easterly direction, then, making a great sweeping bend, flows north to the Gunnison River. Its tributary, Hensen Creek, heads just north of the headwaters of the Animas,

and, flowing east, joins it near where it begins its northward course, flowing through a very deep and gorge-like cañon.

Turning westward, the Uncompahgre headwaters are found against the head of the Animas, and the tributaries of this stream, all flowing in deep and abrupt cañons, drain the northern portion of the divide, in which Cement and the North Fork of Mineral Creek take their rise. The divide between the Animas and Uncompahgre is not difficult, nor that between the headwaters of the North Fork of Mineral Creek and the Red Fork of Uncompahgre; but the tributaries of this stream, and the stream itself, can be followed in any case but a few miles from their heads. To all intents and purposes, the headwaters of the Uncompahgre are shut off from the outer world save by way of the headwaters of the Animas, the Uncompahgre gorge which begins at the mouth of Red Creek being utterly impassable. This gorge is from 4 to 6 miles in length, through which the stream flows in its course to the north-northwest.

The western side of the divide is drained by the San Miguel, which by its two main branches collects the waters, and then uniting and plunging into a deep cañon, with sandstone walls, flows northwest to the Gunnison.

The southern side is drained by Cascade and Lime Creeks, tributary to the Animas, below its cañon; and the eastern by the Rio Grande and the southern tributaries of the Lake Fork flowing eastward.

From the outer periphery of the elliptical divide, then, we see the waters flowing in radial directions to all points of the compass as from a dome. Within the periphery, spurs from it fill up with mountain-forms the entire area, save the narrow cañons and valleys of the streams. In these valleys there is no surface of any extent which is approximately level save Baker's Park, a small area of perhaps 2½ square miles; just above the point the Animas cuts through the southern rim of its upper basin. Upon Mineral Creek also are several small flats of inconsiderable extent, mostly marsh land, or else covered with bowlders.

Baker's Park has been described by Prof. J. J. Stevenson in Vol. III of the survey reports, and needs no extended description here, even if minute description were within the proposed scope of this paper. Since his visit, however, Baker's Park, which was then almost uninhabited, has become the center of quite a large mining population. Where my camp was established in 1873, at the mouth of the Cunningham Gulch, where then there were no houses, has sprung up a town of log cabins called Howardsville, built upon both sides of the stream; and at intervals of 4 or 5 miles along the Animas, above and below Howardsville, are incipient mining towns; of these Silverton, near the mouth of Crescent Creek, is quite well built, the houses being in many cases quite handsome frame structures. It is well provided with stores, blacksmith-shops, and bar-rooms. Eureka, 4 miles above Howardsville, and La Plata City, at the Animas Forks, are being quite rapidly built up. Baker's Park will probably within the next five or ten years be well covered with houses and mills.

The most noteworthy feature of the drainage-basin of the Animas is the excessive steepness of its mountains, or at least of those directly bordering the main streams. The height of Baker's Park above sea-level averages 9,400 feet, and the peaks within a mile or so of its surface, exceed 13,000 feet altitude. Slopes of 45° are common, and nearly vertical bluffs for hundreds of feet are not infrequent, as seen along the Animas River above Eureka and on the South Fork of Mineral Creek.

The peaks in this elliptical divide, the dome of the San Juan country, will average over 13,000 feet in height. Those at the vertices of the ellipse, near the headwaters of Lake Fork of the Gunnison and Mineral Creek, approach or exceed 14,000 feet.

About the headwaters of Cement and Mineral Creeks the Animas and Uncompahgre divide, the mountains are lower, and, with the exception of one or two peaks between Cement and the headwaters of the Western Fork of the Upper Animas, which are steep knife-edges of volcanic *débris*—loose fragments of rhyolite or trachyte under as steep gradients as the material will stand—are of rounded slopes, which, though still retaining the characteristic steepness common to the mountains of this entire region, are, as a rule, covered with Alpine grasses, and the soil, though often boggy from melting snow, offers foot-hold for animals in their attempts at climbing or crossing them. The most marked feature in this portion of the divide are the two brilliant scarlet-red peaks between the headwaters of Cement Creek and the Red Fork of the Uncompahgre. They are not of very great height, but the decomposition of the pyrites in the trachytes composing them leaves the entire surface of those beautiful cones a brilliant red, which contrasts strongly with the green bald pates or the sombre brown of the trachytic masses of the neighboring peaks. They attract the eye instantly from any point of view by their brilliancy, and are a well-known landmark. At their bases on the Red Fork of the Uncompahgre is a small area, probably 200 acres, of nearly level ground, which is the locus of a new mining town called, I believe, Park City. The valley is named Red Mountain Valley, and is attained only from the Animas side, except by a rough and steep trail from the headwaters of the Uncompahgre; but this question of communication will be treated in full hereafter in this paper.

From the head of the North Fork of Mineral Creek to the southwestern vertex of the

ellipse there is a very bold range of mountains, unbroken, save in one place, by depressions, but throughout its course marked by exceedingly sharp, and in many places pinnacled, ridges and peaks of brown or bright-red color, and varying in height from 13,400 to 14,000 feet. The single break mentioned occurs at the head of a short branch of the North Fork of Mineral Creek, which flows down from the west about 1½ miles above the junction of the two main branches of this stream. Here is a low place, reaching not far above timber-line, over which the range may be crossed to the head of a tributary of the Lake Fork of the San Miguel. Elsewhere the range is impassable, save at the southwest vertex of the ellipse, where a steep trail crosses to the trout lakes. At this southwest vertex is quite a group of lofty mountains, in which the Dolores also, in addition to the San Miguel, Mineral, and Cascade Creeks, takes its rise. Between this group and the eastern rim of the Animas Basin runs a very high ridge, broken only by two depressions, one at the head of Cascade Creek, the other west of Sultan Mountain, the double-capped peak which closes Baker's Park to the southward. Neither of these points are below timber-line, and are not, practically speaking, *passes*, but wriggling trails pass over each. This portion of the rim is noticeable as presenting on its southern side the only stratified rocks in the entire inclosing-walls of the Upper Animas Basin, the gray and red limestones and sandstones of the Carboniferous series, the formation elsewhere being mainly rhyolite and trachyte, seamed with quartz and metalliferous veins.

The eastern portion of the divide presents a clump of peaks about the head of Cunningham Gulch, including Kendall, Blair, Hazleton, and Galena Peaks, approaching or exceeding 13,000 feet in altitude. To the north of these, until we reach the lofty group already mentioned south of Handie's Peak, the divide is rolling, of nearly even crest, cut through by the cañon of the Upper Animas about Eureka Gulch, where bluff-like walls are presented. Within the periphery of this inclosing-rim the only peak worth mentioning is King Solomon's Peak, or Tower Mountain, a rude but symmetrical cone, rising from a broad base north of west of Howardsville to a height of 13,550 feet above sea level. Its nearly perpendicular slopes facing Howardsville are seamed with quartz veins, several of which are silver-bearing.

Spurs and subordinate ranges.

Between the streams flowing outward in every direction from the oval-shaped rim of the Animas Basin, extend short spurs and ranges of mountain-peaks, in some cases exceeding in beauty of outline, in height, and in boldness, any portion of the dome itself. Beginning at the northeast vertex of the ellipse, as before, we have, first, between the two main forks of Lake Fork of the Gunnison the Lake Fork range, trending north 85° east; next, the "Uncompahgre group," the drainage-axis trending north 45° east, which, with minor ridges, such as the Ibex or Mountain Sheep spur, fill up the space between the Lake Fork and the Uncompahgre. West of the Uncompahgre, springing directly from the dome at the northwestern extremity of its shorter axis, and trending north 75° west, is the Unaweep Range. From near the southwestern vertex the Sierra San Miguel, separated from the dome by a low depression, trends to the west between the Dolores and San Miguel. From the southwestern vertex, trending 20° west, the rib forming the divide between the Animas and Dolores, and ending in the high group of the Sierra La Plata, extends for twenty-five or thirty miles. From the southeastern edge of the rim, and trending S.° east, the Needles, or Sierra Los Pinos of Newbury, extends about the headwaters of the Los Pinos and Florida, cut by the cañon of the former stream. On the eastern side the two prongs of the continental divide complete the circuit.

Analyzing the topography of this division, then, without reference to geological axes or their origin, but regarding simply the topographical features as they exist, the seemingly confused mass of mountains about the headwaters of the Animas River takes the definite form of an oval or oblong nucleus, with radial spurs as the frame or skeleton; secondary spurs, and long sweeping slopes of the original plateau cut by water and ice fill up the area with mountain-forms which at first confuse the mind and give rise to a feeling of bewilderment. Proceeding, however, in the survey of this area with a knowledge of the analysis above, it is comparatively easy to unravel the mazes of this labyrinth and to depict them.

The central rim is first defined, and afterward, by winding in and out around the extremities of the radial-divides, the intermediate valleys and their limits, *i. e.*, the spurs, themselves, may be defined one by one.

The headwaters of the Lake Fork of the Gunnison and of Hensen Creek.—The Lake Fork Range.

The Lake Fork heads in quite a wide and long cup-shaped valley on the west side of Handie's Peak, above timber-line, where, after collecting the numerous small rills which flow down the steep slopes surrounding the American Basin, it flows out first in a northerly direction, then sweeping around to the southeast, and finally to the east and

north, toward the Gunnison, describes, in its course from its head to the mouth of Henson Creek, a large and symmetrical reversed S. Just below its first bend, and at its junction with a small stream from the north, is a narrow valley, probably 200 yards wide, called Burroughs Park, which extends, with few hummocks over its surface, for 2 miles down the stream, which then begins a rapid fall in a secondary cañon, from which it emerges near the point the stream changes its course from southeast to east. Here begins another narrow park-like area, covered with grass and willows at the point Lake Creek is joined by Cottonwood Creek, which drains the eastern slopes of the Handie's Peak mass, and flows down in a gorge-like cañon from the south of west. This park-like area extends with but one break nearly to the upper end of San Cristobal Lake, a beautiful sheet of water which entirely fills up the bottom of the Lake Fork Cañon for 2 miles of its course at the western extremity of the Lake Fork Range.

From the lake to the mouth of Hensen Creek the stream is in narrow secondary cañons, and the surface of the bottom of the great cañon is filled with rolling hillocks of *débris* from the mountain-slopes. From this point, where there is a small tract—probably 300 acres—of level ground, to the point the wagon-road leaves the valley of the Gunnison, the stream is alternately bordered by small parks insignificant in extent and by abrupt walls of volcanic rocks of small height, the lower extremities of the slopes from the rims of its cañon cut through by the stream. Throughout this entire portion of its course the Lake Fork flows in a deep cañon, tolerably wide at top, varying in depth from 5,000 to 3,000 feet, bordered on the south and east by the well-defined rim already described of the plateau north of Clear Creek, and by the Cannibal Plateau, and on the north and west by the Lake Fork group of peaks and the summit of the Uncompahgre plateau. The width of the cañon at top will average about 4 miles.

The stream below the lake will average from 80 to 100 feet in width where its current is not unusually rapid, and from 2 to 4 feet in depth. Between the lake and the mouth of Hensen Creek it plunges in succession over two picturesque falls, the lower 80, the upper over 100 feet in vertical height.

Hensen Creek is about one-half the volume of the Lake Fork, rises in a wide extent of rolling highlands north of the headwaters of the Animas, and plunging rapidly downward, flows east, cutting the tremendous cañon in some places 5,000 feet in depth, bounded by abrupt walls, and very narrow at bottom, which separates the Lake Fork group from the plateau upon which stands the Uncompahgre Peak; at its mouth, on the small flat just mentioned, Lake City, the most promising town of the San Juan country, is located.

The mountains and plateaus bordering on the cañons of the Lake Fork and Hensen Creek are from 12,000 to 14,000 feet in height, and the Lake Fork range is situated between the two gorges.

Lake Fork range.—Of the groups of peaks and drainage axes radiating from the Animas divide, the Lake Fork range is one of the few which conveys to the mind of the spectator the impression of veritable mountains. Here the mountain-forms are massive, with clearly-cut and distinct peaks, sharp and decided ridges, and slopes with beautiful and graceful horizontal contours. None of those pinnacles, those thin vertical walls with horizontal tops, those bluffs surmounted with rounded upper surfaces, those flat-topped benches and long-sweeping rolling areas limited by bluffs and cañons, which are so often encountered in this region and convey the idea of eroded plateaus rather than of mountain-chains, are seen here.

Though short, barely 12 miles from the head of the Lake Fork to its bend, there is no portion of the Sierra Madre of Colorado, even, which will compare with it in boldness or beauty. Brilliantly-painted peaks, red, orange, and greenish, with short but full and rapid mountain-torrents fed by the perennial snows of its summit, dashing, falling, and foaming down its steep ravines, with its flanks bordered and limited by the cañons and deeply-cut gorges of the Lake Fork and Hensen Creek, with no foothills softly shaded with verdure sloping down to gentle valleys, but everywhere sharp, decided, and bold.

From any point of view not near the rims of the cañons of the Lake Fork and Hensen Creek, the summits only of this ridge are seen, and seem to be cones rising from sweeping plateaus. On coming nearer, a strange, beautiful, and awe-inspiring sight bursts at once upon the view. A mountain-range, perfect in its details, magnificent in contour, sublime in height, beautiful and gorgeous in color, nearly covered in bass-relief, its base thousands of feet below the general level of the country, sunk out of sight in narrow and seemingly bottomless cañons!

The culminating point of this range forms an appropriate central figure for this masterpiece of artistic nature, this magnificent basso-relievo, and in its symmetry, in its coloring, in its freedom from anything not massive and appropriate, in its silvery setting of mighty snow-banks and rushing torrents, is unapproachable.

The peak itself is pointed and well defined. From the summit a long ridge, sharp and graceful in outline, runs to the east of south for a mile or more, when the mountain falls away in rounded, sweeping curves, in steep slopes, to the bottom of the cañon of the Lake Fork, nearly 4,000 feet below.

On the north side the slopes to the cañon of Hensen Creek are more abrupt, but of the same general character. The peak occupies the vertex of an angle where the divide sharply bends round the head of a tributary of Hensen Creek. It is of a brilliant red color, which continues nearly to its base, but few trees finding foot-hold upon its flanks, save on the southeastern side. This color is due probably to the red oxides of iron in the pyrites of the decomposed trachytes, covering with ashen material or gravelly slides its steep slopes. After crossing the pass at the head of Cinnamon Gulch, a tributary of the Animas, to the head of the Lake Fork, this peak is in full view throughout its entire southern slopes, and, the Lake Fork here taking a bend to the southeast before its final bend to the north, seems to fill up with its slopes the cañon of that stream.

A triangulation-station was made by Mr. Spiller upon this beautiful peak, and he gave it the name of Red Cloud. Its altitude, from cistern-barometer observations referred to camp at its base, is 14,092 feet.

The average height of the peaks of this range, which in all number twenty-seven, is 13,500 feet, many of them exceeding this height.

Uncompahgre Peak and Group.

At the head of Hensen Creek is an extensive area, above the limit of arborescent vegetation, covered with mountain grasses and flowers, separated from the Animas and Uncompahgre Rivers by a quite steep ridge, rising some 500 feet above the general level of this area. It is easy to ride around the dividing line, however, between the northern tributaries of Hensen Creek and the streams flowing north to the Uncompahgre and Gunnison, save at three points where the otherwise nearly even crest of this treeless area is broken by abruptly-rising masses of volcanic material, which will, of course, cause detours to be made to avoid them; but, in spite of the few rough places, it is entirely practicable to ride from the headwaters of Hensen Creek along or near the Uncompahgre drainage-axis as far to the northeast as latitude 38° 10′, or about 17 miles, where the portion above timber-line ends. To attain to the summit of this axis, however, is at best a difficult matter, except by way of the headwaters of the Animas River. The streams flowing down from it to Hensen Creek and the Lake Fork, as well as those running in a northerly direction, all are in deep, rocky, and steep cañons, but few of which are passable, and none of which can be followed without great labor and fatigue in climbing over bogs, rock-slides, and fallen timber.

Between the tributaries flowing northward to the Gunnison or Uncompahgre, sharp, almost rectilinear spurs, exhibiting ridge-like peaks, truncated pyramids, or house-like walls of bare rock, with deep and rocky-sided cañons, extend for from 8 to 12 miles north from the divide, and then break down to even-crested ridges covered with timber, and continuing to the cañon of the Gunnison. This general evenness of crest and the truncated aspects of the mountains appearing above it give that plateau-like impression to this portion of the elavated area about the headwaters of the streams in Southern Colorado, in common with the whole northern rim of the Rio Grande basin.

The three masses mentioned above as rising above the general crest of the Uncompahgre spur are, first, the *Wild Horse*, at the head of the western fork of Ibex Creek, the *Wetterhorn*, and further east, the highest mass in Colorado Territory, the *Uncompahgre* Peak. These three peaks are similar in general outline in so far as that each slopes more gradually—if slopes is a proper word to use for such declivities—to the south and are terminated toward the north by nearly vertical bluffs, the Wild Horse and Wetterhorn seeming to imitate their more massive neighbor, and the latter of the two certainly overdoing the character. The Uncompahgre Peak presents a truncated, terraced aspect, seemingly stratified from successive flows of lava, rising about 1,800 feet above the general level of the divide. On the northern side there is a vertical bluff of nearly 2,000 feet; lesser bluffs extend around the east and west sides, leaving a broken, narrow ridge extending to the south, sloping like the curved edge of a snow-drift to the east, but on the western bounded by vertical ledges of trap and steep slopes of rocks and *débris*. The peak was ascended along this ridge with but little difficulty, except at one point near the summit, where a vertical wall of small height affords a good excuse for an awkward climber to roll down the *débris* slopes to the westward.

In 1874 a large cinnamon bear and her cub were found sportively tumbling and rolling from the summit of Uncompahgre at this point, and came near occasioning the loss of our theodolite and of one of the packers who was carrying it. Just as he raised his head above the ledge the bear happened to be about to look down over the same place and both animals, each rather disconcerted at the proximity of the other, tumbled off the cliff together. Both bear and packer, however, happily escaped further injury than a good fright and a few bruises. This peak, though not a sharp point, makes an excellent triangulation-station, since all of the higher points within a radius of 80 miles from the Sierra La Plata around the horizon can be seen from it, and the peculiar shape of its summit makes it readily recognized from any of the points in return. Its altitude

is 14,409 feet above sea-level, as determined by cistern-barometer and psychometer observations referred to camp at Lake City. The observations of 1874 make it 14,447 feet, but, since barometric observations taken in August generally give results too high, the lower altitude has been adopted.

A description of the horizon as seen from this peak is not given, since this report is already exceeding its proper limits, and the ranges have their physical peculiarities described elsewhere herein.

The Wetterhorn, to the south of west a few miles from Uncompahgre Peak, is a shark's nose in form, and its ascent being unnecessary for topographical purposes was not attempted. It exceeds 14,000 feet in altitude and appears inaccessible.

The Uncompahgre Peak was reached by us by way of the lower cañon of Hensen Creek, and by following up the tributary of that stream heading under it. This is a rough and difficult trail, and it is recommended to any one desirous of viewing the mountain masses in Southwestern Colorado from the summit of their highest peak to reach it either by way of the heads of the Animas and Hensen Creek, or else, after following the Lake Fork of the Gunnison 9 miles below Lake City, to turn to the west, following an Indian trail (which here comes down) as far as to the summit of the divide, and then turn to the left and follow the ridge to Uncompahgre Peak. This is the longer route from Lake City than that up the cañon of Hensen Creek and its tributary, but will occasion less wear and tear upon man and mule and try the temper of either less.

The Uncompahgre spur and group, as defined herein, form the divide between the Lake Fork of the Gunnison and the streams flowing nearly parallel to it to the north. Of these, between the Lake Fork and the Uncompahgre, there are four heading in this divide, which were traced for only about 7 miles north of the Uncompahgre Peak. For this distance they flow in deep-cut gorges and cañons without bottom-lands, but it is not known into what tributaries of the Gunnison they empty before reaching that stream, nor by what names they are known to either whites or Indians. The most western of the four, however, which flows probably into the Uncompahgre, was named Ibex Creek, for here large herds of mountain-sheep were seen grazing, or else bounding over the rocky slopes bordering this stream. I have heard the name "Cebatta" given to the eastern and "Cimarron" to the middle of the three remaining, but do not know whether they are so known.

HEADWATERS OF THE UNCOMPAHGRE.—UNCOMPAHGRE PARK.—UNAWEEP VALLEY AND RANGE.

The Uncompahgre—the stream with the "valley of fountains"—drains the northwestern side of the Upper Animas River. Crossing the divide at the head of the Animas to the northwest, or at the head of Cement Creek east fork, or at the head of the north fork of Mineral Creek, one finds himself upon tributaries of the Uncompahgre. Near the headwaters of these streams (with the exception of that heading against Cement Creek) are small areas of a few acres sufficiently level for explorers, miners, and donkeys to sleep upon, but even these are often boggy and covered with marsh-grass. Mineral City, near the headwaters of that tributary heading against the Animas, is situated on one of these flats near timber-line, and of course is in a bog. In Red Mountain Valley, already mentioned, quite an extensive park (for this region) of several hundreds of acres affords a good town-site, but is effectually shut off from wagon-communication with the rest of the drainage-area of the Uncompahgre by high and ragged mountains, and can consequently be of little service to miners other than those owning property on this fork.

The Poughkeepsie Fork, heading against Currant Creek, east fork, is quite open near its lower portion, but at its head is impracticable even for mules until a trail is cut in the steep mountain-sides.

The entire drainage-area of the Upper Uncompahgre, including Ibex Creek, already mentioned, is a mass of rugged peaks, bluffs, cañons, and gorges. For about 6 miles from its head the main stem of the stream, which heads opposite the Animas, may be followed, but it then enters that tremendous gorge, impassable even for men on foot, which shuts off communication with the beautiful little Uncompahgre Park below. Vertical walls for hundreds of feet inclose the river, which has cut, through the sandstones of Carboniferous age underlying the trachytes and volcanic breccias and scoriæ, a still narrower secondary cañon, or a cañon within a cañon, the upper surface of which being cut to an equal depth by the cañons of streams joining the main stream, prevents passage above the river along its banks, while the bed itself is filled with bowlders and rocks and gorged with fallen trees and logs.

To climb further than the top of the secondary cañon is an impossibility, for here are sheer precipices of thousands of feet in total height. In fact, for its length, the gorge of the Uncompahgre will excel in the rugged grandeur of its scenery, and in its terrible appearance of ruin and desolation, the grand cañon of the Colorado at its deepest point. From the summit of the frustum, a truncated mass upon the western

border of the gorge, to the level of the stream, it is nearly 6,000 feet; to the summit of Blaine's Peak, at the head of one of the tributaries of the Uncompahgre, it is about 400 feet more.

The mountains, or rather ruins, bordering the gorge, especially on the western side and giving it its depth and grandeur, are simply indescribable. If the god of desolation ever exercised his wildest freaks on earth he chose this spot, and cut these lofty masses into those strange forms and weird shapes; those yawning chasms with their red jaws; those beetling precipices with plutonic brows horridly frowning, capping all with slender columns and spires under different angles of inclination to the horizon, which, projected against the sky, seem to be black figures of supernatural origin dancing in glee over the ruin below.

Of the impassable nature of this gorge we speak from sad experience. Bent upon "exploring" it, we succeeded only in tumbling our mules into the cañon, and, after leaving one therein, chose a little worse place to better our trail and succeeded in causing another roll on the part of our pack-mules of some 1,500 feet, which left us without adequate transportation; and had it not been that we found a prospector here with stock, which we purchased, we might have been stuck in that gorge until this day.

The Uncompahgre gorge about 4 miles from its head opens out into first a wide cañon with flat bottom, covered with stones and sand, and finally into a small park-like area, probably a mile and a half in width and from 8 to 10 miles in length, bordered on the west side by a straight line of cliffs of sandstone, capped with volcanic material, gradually decreasing in height toward the north, and on the east by slopes more or less steep from the Uncompahgre group and its spurs. This park, from the Animas River or the headwaters of the Uncompahgre, is reached by a trail over the highest part of the ridge east of the Uncompahgre gorge, and about 2 miles from it, which has already been described in my executive report.

The upper end of the park is quite well wooded along the stream with cottonwood. Scrub-oak attaining 6 or 8 inches in diameter and yellow pines are also found. It is generally well grassed with tall mountain bunch-grass, with wild oats and blue-joint. About midway of the length of the park are hot sulphur-springs impregnated with iron and salts of lime and the alkalies. They have formed a red deposit over 6 or 8 acres of ground which is incrusted with saline efflorescences and bare of vegetation. I observed no outlet to the springs. Their temperature exceeds 120° Fahrenheit; this was the maximum register of our thermometers. Near the head of the park are said to be quite a large group of these springs from which the river and its fork derived their Indian name, "The Valley of Fountains." The entire surface of the park is below 7,500 feet and the greater part of it is susceptible of irrigation.

The Uncompahgre River which flows along the western border of the park is here about 60 feet in width (in August,) and 3 feet in maximum depth.

The lower end of the park is nearly bare of vegetation, save sage, mountain-tea, and cactus of the flat-leaved or prickly-pear variety.

Near the northern limit of atlas-sheet 61*c*, (38° 10′,) the Uncompahgre is joined from the southwest by the Unaweep and the park is closed by ledges which close in upon the stream. Indian trails, here broad and well worn, follow on down the Uncompahgre, with branches running through the Unaweep Valley southwest to the San Miguel, and beyond to the Navajo and Moquis country, crossing the old Spanish trail from Los Angeles to Santa Fé near the bend of the Dolores.

The Unaweep Creek, at its junction with the Uncompaghre, is about two-thirds the volume of that stream, of pure, bright, sparkling water, flowing in a valley, which just above this junction widens out into quite an extensive area covered with sage and scattered bunch-grasses.

The stream about 4 miles above its mouth flares out in fan-shape, its numerous branches draining the northern slopes of the Unaweep range. The entire drainage-area of the Unaweep, with the exception of the flat valley at its mouth, is a series of rounded rolling hills, heavily grassed and without timber other than a few scattered clumps of pines, and along the streams cottonwood, until the steeper foot-hills at the base of the Unaweep spur are reached, which are quite heavily timbered with spruce. The entire valley is a splendid range for cattle, the lower extremity not too high for wintering them.

Several thousands of acres, near the mouths of the streams in the valleys mentioned, are susceptible of irrigation, and would undoubtedly produce good crops.

Beyond the limits of the valleys of the Uncompahgre and Unaweep, the country is a portion of the Colorado Plateau system, the portion of it falling in atlas-sheet 61*c* averaging 9,000 feet altitude, but few rounded peaks north of the Unaweep, and a few miles from it, breaking the general level. These rise only to a very small height above the surface of the country, and are seemingly trachytic or basaltic cones.

The Unaweep spur shoots off from the rim of the Animas Basin near the head of Mineral Creek, and trending north 75° west, forms the dividing ridge between the headwaters of the San Miguel south fork and those of the Unaweep. Its northeastern slopes form the grotesque western walls of the Uncompahgre gorge.

This spur is short, and a well-marked serrated range of peaks. On the Unaweep side its slopes below timber-line are long and gradual, but very sharp and steep from the 10,000-feet curve to the summits. On the side of the San Miguel, however, the slopes are more abrupt as far as to the narrow valley of that stream. The eastern mountains of this spur, especially the group in the northeast, drained entirely by the Uncompahgre, are very much chopped, weathered, and eroded, and exhibit very peculiar features. In some instances the mountain-summits are thin walls of even crests, quite long, and vertical for from 500 to 1,200 feet below their summits. In others these walls are so weathered that prisms and spires only are left surmounting the thin slabs. Several of them are truncated at from 13,700 to 13,900 feet above sea-level, presenting the appearance of pyramidal frustums. In the midst of these strange forms Blaine's Peak, a sharp, decided cone on the extreme northern edge of the range, is situated. It is 14,249 feet in height, exceeding by about 400 feet the masses to the east and south. As just stated, it is in the extreme northern part of the Unaweep range, and is drained altogether by the Unaweep and Uncompahgre; the main stem of the former heading in an extensive cup-like amphitheater southwest of Blaine's Peak, of which this peak occupies the northeastern part of the rim. The southern part of the rim of this crateriform cavity is one of the wall like ridges before referred to; the eastern, a thin and sharp divide between the western fork of the Uncompahgre, Crescent Creek, and the Unaweep. The northern rim is broken down for nearly a mile of its crest in a V-shaped notch, through the narrow bottom of which the headwaters of the Unaweep escape. Blaine's Peak was not ascended, since it was not necessary as a station, the topography having been secured from more easily-attained points. The northern side of this peak is inaccessible on account of the nearly vertical ledges and buttresses of this face. From the south it is necessary to cross the high rim of the amphitheater before beginning the ascent, which must be made along the sharp divide on the eastern side of the cavity. The easiest way to attain the summit would be to cross over the head of the most northerly of the three extreme eastern tributaries of the San Miguel to the southern rim of Crescent Creek, and then to follow this stream to its junction with the main stream and up its seemingly open cañon to the divide mentioned.

This course can be taken upon mules, at least as far as timber-line on Crescent Creek, whence the last 1,800 feet can be made upon foot. Crescent Creek, within 2 miles of the Uncompahgre, cañons, and its course cannot be followed from that stream, even if its mouth could be reached. It empties into the Uncompahgre in the most formidable portion of the great gorge, and is unattainable from that stream save near its head, which can be reached by crossing from Red Mountain Valley west, to the head of the tributary mentioned above. Blaine's Peak may be also reached in this way, but all trails in this neighborhood are excessively steep, and in many places rocky from slides and choked with fallen trees.

SAN MIGUEL RIVER.

The San Miguel River receives the greater part of its waters from its two tributaries, the northern of which drains the southern slopes of the Unaweep group of peaks and portions of the rim of the Animas Basin opposite the headwaters of the north fork of Mineral Creek. The southern, heading against the headwaters of the south fork of Mineral Creek, drains the western portion of the outer periphery of this oval-shaped rim, and, flowing north, unites with the northern, or Gold Run, from 12 to 15 miles from the head of either branch. The northern of these two streams flows for 8 miles of its course in a flat valley 400 yards wide, running with sluggish flow in serpentine folds, and bends from side to side of this valley.

The edges of the valley are bluffs of Cretaceous sandstones, capped on the north by brown trachytes. At the head of the valley is a semicircular *cul-de-sac*, with walls on the eastern and southern sides from 450 to 1,200 feet in vertical height, over which dash in spray the headwaters of this fork. The northern of the three forks into which Gold Run is here divided, flows from its head, 2½ miles distant, in a succession of cataracts, rapids, and falls, the fall being nearly 4,000 feet in 2 miles. Just above the junction of the two forks, Gold Run plunges into a cañon, and, in a series of cataracts, attains in 1 mile a level 1,000 to 1,200 feet lower than the valley above. In the cañon, cut through sandstone, it is joined by the south fork, and flows off in a west of north direction to the Gunnison, as far as can be seen in a deep cañon with shelving sides of red sandstone. The south fork, from the lake 4 miles below its head, flows in steep and deep ravines, and 2 miles below the lake, just above its junction with Turkey Creek, rushes in a series of cataracts into quite a deep cañon, with narrow, grassy bottom, along which runs a trail to the lately-discovered gold-placers on the Gold Fork, at its mouth.

Trout Lake is a beautiful sheet of water, one-third of a mile long, nearly inclosed in brilliant red mountains, skirted with green. Its vicinity furnishes one of the most picturesque and warmly-tinted pictures of mountain scenery in Colorado. The lake abounds with trout, which, however, are not of as firm flesh as the trout of the mount-

ain streams, nor do they attain to as great size. This may be due to the effects of the vegetable mold of the bottom of the lake and the bubbles of gas which are continually rising therefrom through the water. It cannot be seen how the trout reached the lake, since lesser difficulties than the falls and cataracts below effectually prevent their ascending other streams in this area. Southwest of Trout Lake is a wide timbered pass leading to the Dolores River, which, with the Mineral Creek and Cascade Creek, drains the high group of peaks at the head of the south fork of the San Miguel. The Dolores, a few miles below its head, is inclosed in a cañon with steep sandstone walls, from which it does not emerge until the great bend is reached. A difficult and nearly-obliterated trail, traversed last year by Lieut. C. W. Whipple's party, leads down this stream.

San Miguel Mountains.

Between the Dolores and the San Miguel is a detached group of high peaks, three of which exceed 14,000 feet in height, hitherto called the Sierra San Miguel. The drainage-axis is nearly east and west, cut through by the San Miguel River near its cascade. This group reaches its greatest height in a massive peak, with extensive fields of snow on its northeastern flank. This peak was ascended in 1874 by Mr. Spiller, and in our notes was called Glacier Point. Mr. Wilson, of the Geological Survey of the Territories, also ascended it, and called it Mount Wilson. It is the most massive and imposing mountain in Southern Colorado, with the single exception of the Sierra Blanca, near Fort Garland, and is 14,243 feet in height. Two miles east of this great peak is a strange freak of nature. This is a thin column of trap-rock, about 230 feet in height, shooting vertically from a rude cone, forming a slender and well-proportioned column, with rounded summit, cleft in twain to a depth of perhaps 10 feet. Its summit is about 13,150 feet above sea-level, and offers a fine point for triangulation, with the single objection that it cannot be ascended.

To the west of the Glacier Point group are several nearly isolated masses, along the same drainage axis, of which one, an irregular group with a sharp, well-defined cone at its southeastern extremity, is remarkable for the great crater on its southwestern side, from which flows a tributary of the West Dolores. This cone was made a primary triangulation station, and named *Dunn Peak*, in honor of Gen. W. McK. Dunn, Judge-Advocate General of the Army. It is 13,502 feet in height, and being quite detached from the lofty ranges, is a much more marked feature of the landscape than peaks of the main group exceeding it in height. West from the Dunn's Peak Crater is a beautiful sharp cone, perfectly symmetrical, reaching but little over 12,000 feet. It is the most beautiful peak I have ever seen. It is entirely detached from the other mountains, and rises, a solitary, graceful peak, 3,000 feet above its base. It was named by me West Point. This is the last peak to the west until the Sierra Abajo and Sierra Le Sal are reached. South of these detached masses, and between the two main forks of the Dolores, is a small group of peaks, less than 13,000 feet in altitude, rising abruptly from the cañons of the Dolores.

From West Point the horizon is a succession of nearly flat sweeping plateaus from the southwest around to the north. The tributaries of the San Miguel and Dolores, which head in the San Miguel drainage-axis, all cut deep cañons in the sandstones.

The upper surfaces of the rolling country bordering the San Miguel and its tributaries, as soon as they emerge from the mountains, are most luxuriantly clothed with the richest of grasses. Wild oats and the tall seed stalks of various mountain grasses reach to a man's thigh, and the whole region resembles in the latter part of August an immense field of waving grain; clumps of quaking aspen and of yellow pine vary the surface and beautify the landscape. The region is too high for other purposes than summer grazing, except in the narrow cañons of the streams, where occasional small plats sufficiently low for cultivation may be irrigated. Game seems to be quite abundant; wild turkeys were seen upon the San Miguel South Fork. On the Dolores, bears, both black and cinnamon, are frequently seen, and sleep was nearly impossible for us on account of the continuous and multiplied cries of the California lions. Small game, such as grouse, and, on the bald-topped mountains, ptarmigan, or mountain quails, and in the streams mountain trout are easily captured.

Divide between Dolores and San Juan, Sierra La Plata, and upper drainage-area of the La Plata, etc.

The radial drainage-axis, which from the head of the South Fork of Mineral Creek trends south 35° west as far as to the Sierra La Plata, is (with the exception of a few trachytic masses, less than 13,000 feet altitude, south and west of the Dolores headwaters) a ridge of comparatively low broken hills, covered with timber, and drained by Hermosa Creek, a tributary of the Animas, and by steep rills flowing into the cañon of the Dolores, until the group of mountains known as the Sierra La Plata, twenty-six miles from the rim of the Animas Basin, is reached. Here this drainage axis attains a maximum height of 13,300 feet at the head of the North Fork of the Rio Los Mancos, where the highest of the La Plata group is situated.

The Sierra La Plata is not, properly speaking, a Sierra—a single range of serrated peaks—but is a group of peaks and mountains gradually lessening in height to the southward, and from its highest peaks, which occupy the northern part of the area covered by the group, breaking rapidly down to the northwest to the level of the Dolores. The Rio La Plata heads in the northern portion of the group and flows west of south, bordered for 13 miles of its course on either side by peaks of the La Plata group. The eastern side of this double range is drained by tributaries of the Animas River, the western slopes by the two minor forks of the Rio Los Mancos. To the northwest the water flows into the Dolores. The mountains are composed largely of sedimentary rocks in many places, altered by trap-dikes and igneous flows. This group is now attracting considerable attention from the extensive placer or auriferous bar at the gate-way of the Rio La Plata, and on account of the rich lodes of gold and silver ores lately discovered in them.

The streams flowing from the La Plata Mountains are quite insignificant. The La Plata and Mancos are about 40 feet in width and perhaps a foot and a half deep. Junction Creek is small, and the Hermosa, which has quite an extensive drainage-area, receives but little of its water from these mountains. It is, however, quite a large stream, equal in size to either the La Plata or Mancos.

Of the valleys of the streams flowing from the La Plata group those of the Mancos and La Plata only are important. On the Mancos, near the junction of the two forks, is, perhaps, 1½ square miles of arable land, extending down the borders of the streams and along the stream at intervals; below are said to be good farm-sites.

The La Plata, within the limits of the recent purchase from the Utes, is too high for certainly-successful agriculture, but below the boundary are several thousands of acres which, if the stream furnishes sufficient water, will produce good crops. The Utes now raise corn, squashes, and melons with success, and roots and grains would, no doubt, successfully mature.

Between the Mancos and La Plata are several small parks well grassed, and the hills are all covered with mountain grasses. Quite extensive ranges for cattle can be found here. At present about four thousand head of sheep are grazed, with the permission of Ignacio and his band of Utes, who, notwithstanding the purchase of 1873, still claim the land.

The Mancos, a short distance below the junction of its forks, enters its cañon, cut through the Mesa Verde, a mesa several hundreds of square miles in extent, covered with wood, and much cut by cañons; an Indian trail leads through the cañon.

The drainage-areas of Junction and Hermosa Creeks are worthless, unless coal of good quality exists in the rocks bordering the streams. There are no valleys or flats of any extent, but the entire area, particularly the drainage of Hermosa Creek, is a mass of a small hills and cañons with vertical walls of sandstone, a chopped-up area of tangled cañons and worse-tangled fallen timber. Indians have made no trails through the Hermosa drainage-area, and whites have no occasion to.

SOUTHERN RIM OF ANIMAS BASIN, ANIMAS RIVER AND PARK.

The southern side of the rim of the Animas Basin is cut through by the Animas River, which escapes to the southward through a deep-cut gorge, which, though continuing as a close but not deep cañon below that point as far as to Old Animas City, 25 miles in air-line below its head, ends as a deep, formidable obstruction at the mouth of Cascade Creek, 15 miles below Baker's Park.

This cañon, to my mind, for reasons which will be given hereafter, is a very important element in the problem of routes of communication outward from the extensive and prospectively valuable and rich mines of the Animas, Eureka, and Uncompahgre mining districts. It is avoided now as utterly impracticable, and, unfortunately, the heavy rains and snows of the month of September so much delayed the work of the party that we could not make a detailed examination and profile of the cañon, or even devote sufficient time to it to find out whether it is passable or not. Two stations were occupied along the western rim of the gorge, but the surface of the river below was not reached.

From the foot of Baker's Park to the mouth of Cascade Creek the cañon is bordered by high peaks of quartzite, (with the exception of the eruptive rocks at Sultan Mountain,) reaching in some cases over 5,000 feet above the stream, which inclose the river in a cañon narrow at bottom, but opening out at top until from the stream to the summits of the peaks bordering it are intervals of from 1 to 2½ miles, or the mean slopes of the cañon walls vary between twenty-five and forty-five degrees. Near the stream the slopes are more nearly vertical, and are cut through metamorphic rocks as hard as flint; Cascade Creek, near its mouth, flows in a similar cañon, but not so deep.

From the mouth of Cascade Creek to the head of the Animas Valley, about 11 miles, the Animas flows in a lesser cañon, cut through the eastern edge of the floor of a valley about 1½ miles wide, bordered on the east by a ridge gradually decreasing in altitude to the south, and on the west by a vertical ledge of red sandstone, which limits the drain-

age area of the Hermosa to the eastward. Above the mouth of Cascade Creek the country is very rugged, and broken by the deep-cut valleys and steep ridges between of the streams draining the southern side of the Animas rim. This entire section below high-timber line is covered with fallen timber and many little bogs and springs, which, in addition to steep grades, make the trails over the high passes at the heads of Cascade and Lime Creeks difficult and unsatisfactory.

Trails of this character, steep, boggy, and obstructed with logs, lead over the heads of Cascade Creek to the Dolores and to the south fork of Mineral Creek, and over the head of Lime Creek to Baker's Park.

The mountains in the angle between Cascade Creek and the Animas are of metamorphic rocks, quartzite, and farther west and north on the southern slopes of the rim are trachytic, overlying extensive exposures of the limestones and sandstones of the Carboniferous series; which latter give, by their worn and exposed faces and small dip, mesa-like bunches or berms at the bases of many of the trachytic slopes, notably near the headwaters of Cascade Creek and at Engineer Peak, ascended and described by Lieutenant Ruffner's party in 1873.

South of Cascade Creek the rolling floor of the bench or plateau valley cut through by the Animas, along its eastern edge is heavily grassed, and quite well watered by streams flowing from cliffs in the sandstone bluffs bordering it to the west, and by lagoons and lakes on its surface near the river. It is about 8,600 feet in altitude, and is a fine summer range for a small herd of cattle. At Animas City the river emerges from the low walls of its cañon, and the valley opens out a short distance below to a width of from one-half to 1 mile and extends for 10 or 12 miles, (within the area purchased from the Utes,) its nearly flat surface broken in one or two places by low, rounded hills rising, perhaps, 25 to 50 feet above the surface of the valley. In this park or valley very fine crops of corn, wheat, oats, and barley were raised last year, and all of the usual products of the vegetable garden were growing to perfection. Up to the 1st of October, as I am informed, there had been no frost, which the green tops of growing plants further attested. Potatoes grow to great size; single bulbs weighing two pounds or more each were in several instances found among the few purchased for the use of the party, and were of fine flavor and texture, solid throughout. These were said to have been grown from the miserable little refuse bulbs obtained at Tierra Amarilla, N. Mex.

The Animas River is here about 100 feet in width and 3 feet deep, of sluggish flow, and very tortuous; bordered near the center of the valley with soft banks of alluvium, and in places in its bed obstructed with quicksands. Fords, however, are found at several places in the valley where rapids occur. Junction and Hermosa Creeks furnish sufficient water to irrigate the western side of the valley, and the eastern can be irrigated by a ditch starting below Animas City, where the banks of the stream are not too high. There are probably, in all, beeween 3,000 and 4,000 acres of arable land of fine quality in the Animas Valley, north of the boundary of the Ute reservation, varying in altitude from 6,400 to 6,800 feet. All of the desirable ranches have been homesteaded, and will, it is expected by the owners, prove sources of wealth more certain than the silver lodes which attract their customers to the mines above.

Old Animas City is situated on a low bunch of gravel overgrown by quite a forest of large yellow pines. Elsewhere, near the valley, there is abundant timber and fuel.

Just below old Animas City, which, by the way, is not inhabited, are several springs of carbonated water impregnated with soda salts and with sulphur, and of quite pleasant taste. The temperature of one was taken, and found to be 107°.3 Fahrenheit. They have formed a dirty ocherish yellow deposit about them.

The Needles or Quartzite Crags.

East of the great cañon of the Animas and south of the headwaters of the Rio Grande, about the headwaters of the Rio Los Pinos and Florida, is a group of crags of quartzite rocks, reaching to an altitude above sea-level of 14,000 feet. The forms of these crags are so unusual in the mountains of Colorado, and especially here where rounded summits and large masses with sweeping curves and outlines are so frequent, that they deserve mention, although the area covered by them is very small, and in all probability is forever useless, unless unexpectedly mines of silver or gold are found. Among these there are no slopes covered with grass, no valleys, scarcely foothold for pines on their slopes, but everywhere thin crags and slabs with knife-edge or saw-teeth summits, as a rule wholly inaccessible, pierce the clouds, encircling like a crown the heads of the western tributary of the Rio Los Pinos and short tributaries of the Animas above Cascade Creek. Nowhere in Colorado can be found such steep slopes, such shapeless crags, such rocky and impassable ravines, such generally detestable characteristics and features as are here seen.

The hard metamorphic rocks are shivered along their cleavage planes for hundreds of feet, leaving here odd pinnacles, there the likeness of the shattered outspread wings of some gigantic bird, and again of the grim grinning teeth of Death.

Under the most favorable circumstances one must be impressed with a feeling akin to terror in merely viewing these lofty crags and these deep-cut gorges between them; but, under the conditions they were visited in 1874, by Mr. Nell and myself, they cannot fail to leave behind a lasting dread of them and of everything connected with them.

On the 1st of October, after considerable difficulty, we succeeded in reaching the limit of tree-growth on the flanks of one of the most southerly of these crags, by crossing the Atlantic and Pacific divide at the head of the Ute Creek, tributary to the Rio Grande. Camping here at the head of a profound gorge 11,750 feet above sea-level, we awaited the next day to make a triangulation station upon apparently a thin slab, which from its appearance from the north we had christened "The Hunchback." In this, however, we were destined to disappointment, for it began to snow, and the next morning the ground was covered to a depth of 6 inches. Thin fleecy clouds were floating about, and cheated us with the hope that the storm was spent and the peak could still be made. We delayed, therefore, until the summit of the crags should be visible, but the clouds only thickened, and soon again the snow was flying so thick and fast that we could not see 50 yards; and to make the white gloom more visible, and our condition more amusing, perhaps, forked streams of electricity, followed by tremendous bursts, claps, and rolls of thunder—which, attending a snow-storm, was to me a special and unheard-of exhibition of heavenly wrath—leaped from cloud to crag, in this group of natural lightning-rods, in the most inexplicable and to us unassuring and unnecessary manner. It blew and blustered, stormed, crashed, and thundered as if heaven were determined to level and blow away in dust these already shattered and ruined masses of flint. All day it would storm and snow, and at night the stars would come out twinkling, cheering us with a vain hope for the morrow.

Three days we lay here unable to move, while those light, beautiful, almost impalpable flakes were gradually enveloping us, removing from us hopes of escape, and making life miserable by insinuating themselves like fog, everywhere, into our tents, into our beds, almost into the pores of our skins. We dare not move, lest, lost in this white darkness, we should be precipitated over some ledge or be lost in banks of snow drifted by the winds. Our poor mules, which, in their previous revolutionary attempts to subvert the established order of their packs by erratic excursions down hill on *side trips*, had succeeded only in crippling themselves; motionless, and covered with as much snow as would lie upon their backs, stood gloomily around, gazing at us with that dumb expression of unutterable misery, despair, and reproach which even mules can assume, and which appeals irresistibly for sympathy and aid.

On the morning of the fourth day the snow was slowly falling, and the fleecy clouds rolling hither and thither above us and in the gorges below, every now and then giving us a glimpse of sun and snow-crowned crag or deep-cut gorge, showed to us poor shivering mortals that the storm was nearly spent; our mules gained courage, and began to break their three days' fast by ravenously devouring the twigs and branches of the scattered shrubbery and the grass obtained by pawing the deep snow.

We hardly needed the additional spur to exertion given us by our cook, who, when preparing our breakfast, incidentally remarked, as a matter of no consequence, as he patted his bread into the oven, "That's the last loaf," adding, however, this additional unimportant bit of news, "We've got lots of beans."

We excavated our packs from the snow, and packing our hungry mules, commenced with many misgivings to retrace our steps. Our supplies were at Pagosa Springs, 60 miles distant, and it was necessary to first cross the continental backbone to the Rio Grande side, and then again recross it to the head of the eastern fork of the Los Pinos. The snow varied from eighteen inches to 4 and 5 feet (where drifted) in depth, and the divide where we crossed was at both places over 12,000 feet in altitude. It was necessary for us to dismount and tramp down the snow to make a passage-way for the loaded and nearly famished mules, which, as fast as the leading animal would become exhausted by the impeding snow, were changed in their order of travel. We succeeded fortunately in reaching each night places where, in lower altitudes, the snow had partly melted and left the grass sticking through it for our animals, (otherwise we would inevitably have lost them,) and in five days, tired out, we reached our camp at Pagosa, having subsisted entirely upon our cook's "plenty of beans" for that interval. This article of food had been persistently avoided by us hitherto, but most modestly asserted itself in our hour of need.

The quartzite crags are inseparably connected with this disagreeable experience, and in my condemnation of their countenances I am deeply prejudiced against them.

HEADWATERS OF THE RIO LOS PINOS, RIO FLORIDA.

Crossing the divide at the head of Hine's Fork of the Rio Grande del Norte, we find a stream flowing in a deep and rocky gorge through the midst of the crags just mentioned to the east of south. Northwest some 10 miles and within 4 miles of the cañon of the Rio Grande, heads under Simpson's Pyramid and flows through a flat, badly drained

summit far below timber-line the east fork of the same stream—the Rio Los Pinos. This flat summit of the Los Pinos Pass is strewn, especially just above the head of its cañon, with immense bowlders of granite, sometimes 20 feet in diameter. The pass resembles in this respect, over very limited areas, however, the areas of drift in some of our Eastern States. Along the headwaters of this stream, indeed, are the only granite rocks encountered in this whole group of mighty mountains, save a few exposures upon the Piedra headwaters. Ten miles below its head the East Fork cañons, and for 14 miles flows through a cañon with bluff-like sides, the stream choked with granite bowlders and the banks with fallen trees. Below the cañon the stream is joined by its West Fork, before mentioned, which, emerging from its quartzite gorge, flows in a beautiful little valley several miles in length above the junction, and averaging a half to two miles in width, the latter being the diameter of the valley at the junction of the streams. Below this point the valley is narrow; in places covered with magnificent yellow pines, and at others with a few grassy valleys. The stream is alive with the finest and largest of mountain trout. In its cañon the Los Pinos is joined by two quite large tributaries flowing down from the easternmost of the quartzite crags; but from the east side, where there is near the border of the stream a thin range of mountains reaching 12,000 feet, the tributaries are very short and insignificant. The Rio Los Pinos below the junction of the two forks is 80 feet in width—a bold, deep, and pure stream of sparkling snow-water. Quite extensive strips of land along its banks are susceptible of irrigation.

The Florida, between the Los Pinos and Animas, is of nearly the same character. It is about 35 feet in width and 3 feet maximum depth, rises in the southernmost of the "Needles," and drains the sloping ridges above timber-line between the West Los Pinos and Animas Rivers. Its valley is similar to that of the Los Pinos, but there is above the boundary of the reservation but comparatively little arable land upon its border, the upper portion of the valley above the bend of the stream being narrow and high. South of the junction of the two main forks of the Los Pinos, and drained by the two streams mentioned and those east of them, and within atlas-sheet 61C, the country is rolling, the high lands averaging 8,500 feet, eroded by water, exhibiting along the stream frequent low bluffs of sandstone of Cretaceous age. It is well timbered with large yellow pines, oftentimes 3 feet in diameter, and for 50 or 60 feet without a branch or knot. Everywhere is fine grass.

We made the first trail through the Los Pinos Cañon. The Utes, and whites after them, avoid the cañon by turning to the left above its head, and then following along the eastern slopes of the divide between the Los Pinos and Piedra, near the summit of the ridge, and come down again to the Los Pinos at the beautiful little park above the junction of its two forks. If the bogs were cut out of the trail the cañon would offer better grades, a harder surface, and a shorter route than the trail above it, which is generally execrable; as it is, however, the cañon can only be passed by work. The stream is well peopled with beaver colonies, and on the small flats bordering it within its cañon many deer were seen.

On the Florida and elsewhere in the San Juan area, coal has been discovered, and is said to have good coking qualities. If it be as represented, it will prove of great economical importance in the smelting of the ores of the mines in this area, especially if the route via the Animas Cañon is ever opened.

The *mines* of this, the most important part of the area surveyed, will be briefly noticed hereafter in this paper.

3d. FROM THE LOS PINOS PASS TO THE SUMMIT MINING DISTRICT.

This division of the Rio Grande loup was only partially visited by my party, but other parties of the expedition during the past two seasons completed its survey.

From the pass mentioned to the headwaters of the west fork of the Rio San Juan the range is of less height, but more broken and cut by cañons than the opposite or first division, while at the same time exhibiting the plateau-like aspect in many of its masses.

With the exception of a few peaks near the headwaters of the western branch of the Piedra, there are no marked and dominating peaks, but a great number of small mountains, with ridge-like, rounded, or flat summits along the divide, in some instances peaked and reaching 1,000 feet above timber-line, but as a rule not exceeding 12,200 feet.

The passes from the Rio Grande to the heads of the Piedra are all below timber-line, and, except at a few places where bluffs prevent, the dividing-line between the waters of the Rio Grande and Piedra can be followed on horseback from the head of the Los Pinos as far as to the head of the eastern tributary of the Piedra. This was done by me the past season without great difficulty. On each side of the divide, vertebral ribs between the streams flowing into the Rio Grande and Piedra, separated on the southern side by very steep, rough cañons, make travel nearly impossible, and the attainment of the divide from the valleys of the Piedra area a very difficult undertaking.

The peaks retain for 6 or 7 miles south from the divide a nearly uniform height, and then in a very abrupt fashion break down in nearly vertical slopes to the level of the streams which flow through narrow gateways in these outer bluffs to the open country to the south of them. The ribs between the streams to the northward, or on the Rio Grande side, are wider and with more unbroken and rounded summits, presenting between the Los Pinos and Macomb's Peak smooth crests or bench-like tops, bounded by steep walls or slopes toward the streams. Between the San Juan and Piedra Rivers is a very decided spur, or a serrated range of mountains, varying in height from 12,560 to 13,150 feet, which, trending 15° east of north, continues from the Pagosa Peak, the most southerly of this range, nearly to the Rio Grande. On the north side this range forms the divide between Thunder Creek, heading under Macomb's Peak, and Hot Spring Creek, both tributary to the Rio Grande. Its extremities are more gradual slopes than usual in these mountains, on one side sloping from below timber-line on Pagosa Peak gradually down to the oak-covered hills of the Piedra and San Juan basin, and on the northern ending in large, massive, rounded mountains, sloping with smooth slopes to the Rio Grande between Bristol Head and Wagon-wheel Gap. Around its northern end the Rio Grande describes a great curve before cutting the cañon at Wagon-wheel Gap.

Six miles east of Macomb's Peak is another quite high rib from the continental divide, serrated to the south, and drained by the San Juan west fork, but to north showing round, flat tops between the western tributaries of the south fork of the Rio Grande and Hot Spring Creek. From this rib to the north and west to the summit mines the country is mostly below timber-line and cut by steep cañon of the tributaries of the south fork of the Rio Grande, and quite heavily timbered.

Between the south fork and the San Luis Valley the mountains again rise above timber-line and extend from the rounded, dome-like mass southwest of Del Norte to the west of south, rising to a high sierra about the heads of the eastern fork of the San Juan. These mountains were not visited by me, but were surveyed by the party of Lieutenant Morrison. They were also visited by your party in 1874. From the head of the Piedra to the summit mines there is no traveled trail crossing the divide, but at the head of the west fork of the Rio Grande, which empties into this stream below Antelope Park, I crossed a trail on the summit which at one time seems to have been well traveled by the Utes. It follows up the middle fork of the Piedra and crosses the divide below timber-line. It will never be available as a wagon-route. Another trail of the same character leads across the headwaters of the south fork Rio Grande. However, all mountains can be crossed by pack-trains with a little work, and this division is not naturally as impassable as the first. The divide can be reached in many places, but the cañons are rocky and steep. The prevailing rock being still the brown trachytes met with throughout the Rio Grande loup; a coarse-grained, red feldspathic granite is occasionally seen.

As soon as they leave the mountains the tributaries of the Piedra flow through valleys, of greater or less width, similar to those on the Los Pinos and Florida, all of which are splendid cattle-ranges, and in great part sufficiently low for agricultural purposes.

The Piedra, however, cañons up a few miles north of the southern boundary of atlas-sheet 61*c*, (37° 20′,) and the agricultural lands are limited thereby. Between the streams are low hills, covered with great pines and undergrown with scrub-oak, the acorns of which attract in the fall many deer, making this a favorite hunting-ground of the Utes at this season.

The San Juan for 15 miles of its course above Pagosa hot springs is bordered by similar valleys, ranging in altitude from 7,057 feet at Pagosa to 7,700 feet at the point the trail to the head of the south fork of the Rio Grande leaves its western tributary. On the south fork of the Rio Grande are no valleys, save one too high for agriculture on its eastern branch, and another more narrow on the upper portion of the middle fork. The western tributary is in a cañon its entire length.

The valley of the Rio Grande itself, above Del Norte, has already been well described in the reports of Lieutenant Ruffner and Prof. J. J. Stevenson, and needs no extended description here. From the head of Antelope Peak to Del Norte the river flows in a succession of narrow valleys well grassed, but too high for agricultural purposes, until the mouth of the south fork is reached, where potatoes succeed in maturing. In this distance the stream is inclosed by cañons for about 6 miles of its course at Wagon-wheel Gap and below. From the mouth of the south fork to Del Norte is quite a wide valley, (averaging 1½ miles,) much of which may be easily irrigated. At Del Norte the Cerritos of basalt close in, forming a comparatively narrow gateway in which Del Norte is situated, and through which the river flows out into the San Luis Valley. At Del Norte the work of the season was practically brought to a close by snow.

MINES.

No special examination was made by me in person, but the following general information was gained from miners and others interested in the mines, and from the observations of myself and party made at random while pursuing our topographical work.

Districts.—At present the mineral-bearing region is divided into six mining districts. On the *Animas* are the *Animas districts*, extending along the Animas from 2 miles above Howardsville to the south and including the southern and southwestern portion of the rim of the Upper Animas basin, and the *Eureka district*, adjoining the Animas district, and including all the country in the northern portion of this basin as far as the divide. On the *Uncompahgre*, the *Uncompahgre district* includes the drainage-area of the Uncompahgre above its gorge. The *Blaines Peak*, or *Mount Sneffels district*, the lower mineral region, of which *Ouray* is the town.

On the Lake Fork is the *Park district*, extending from the headwaters of the fork to Cottonwood Junction.

The *Lake district*, including the Hensen Creek Mines, and those upon the Lake Fork north of Cottonwood Junction.

In the Animas districts the ores are mainly argentiferous galena, with, in some cases, traces of gold, assaying from 40 to 60 per cent. of lead, and from 60 to 400 ounces of silver per ton; assays of culled ore have been made far up in the thousands of ounces. The ores are contaminated by iron and copper pyrites. The Little Giant Mine and others in Arrastra gulch are gold-bearing, the matrix being quartz with a streak of manganese in the form of ripidolite, which seems to be richest in gold. Gray copper ores are also frequent along the Upper Animas. On the Uncompahgre the veins are of immense width, with pay-streaks varying from 10 inches to 4 feet; the ores on the southern side of the district being smelting, while those on the northern fork are in great part free milling ores. Petzite, gray copper, bromide of silver, ruby-silver, native silver, and antimonial silver ore, and various sulphurets assaying high in the thousands of ounces, have been discovered. Many of the lodes here show traces of gold.

On the Lake Fork of the Gunnison and on the Hensen Creek are about 800 locations, the ores being, as a rule, of lower grade than in the Animas, Eureka, and Uncompahgre districts, but of the same general character. Several of the mines, however, give very rich ores, as, for instance, the Hotchkiss lode gold and silver assays from $200 to $12.000 per ton, averaging $1,500; *Ute lode*, $200 to $1,200; *Little Chief*, gray copper ore, $200 to $15,000; *Lone Chief*, petzite and black sulphurets, $150 to $800, and perhaps a dozen others of high-grade ore. The above veins are mentioned only for illustration. I personally know nothing about them, except from information which I consider reliable.

Below Lake City are several lodes of gold bearing quartz assaying from $20 to $1,240 per ton.

Up to October, 1874, the following assays have been made in the Uncompahgre district, and will show what is considered a fair average of all the lodes and claims in the San Juan country, near the surface. The ores are generally low grade, but an unusual number of very rich mines have been discovered, when we consider that one good lode where transportation can be secured is sufficient to assure the prosperity of a mining district. Witness Pioche and other mining districts in Nevada:

46 assays,	from	5 ounces to	25 ounces	per ton in silver.
19 assays,	from	25 ounces to	50 ounces	per ton in silver.
47 assays,	from	50 ounces to	100 ounces	per ton in silver.
18 assays,	from	100 ounces to	300 ounces	per ton in silver.
9 assays,	from	300 ounces to	500 ounces	per ton in silver.
11 assays,	from	500 ounces to	1,000 ounces	per ton in silver.
5 assays,	from	1,000 ounces to	2,000 ounces	per ton in silver.
2 assays,	from	2,000 ounces to	3,000 ounces	per ton in silver.
3 assays,	from	3,000 ounces to	5,000 ounces	per ton in silver.
1 assay,	from		6,300 ounces	per ton in silver.

The above may, of course, be regarded as results of assays of picked ores near the outcrop. Ores worth less than $150 a ton at present prices for milling (averaging $75 per ton) and for transportation ($100 to $120 a ton to Del Norte) will not pay to work, and for this region are classed as low grades.

New discoveries are still being made almost everywhere in this group of mountains, and the known area covered by the mineral croppings and lodes is continually widening. I found float galena and cupreous ores of silver near the head of the San Miguel, and picked up several small nuggets of gold from the rocky bed of one of its tributaries. Doubtless there will be found rich lodes of gold and silver here also. The veins throughout the region are well defined, with good walls, and give, by their persistency along the surface, every outward evidence of permanency. They trend northeast to southwest, northwest to southeast, and near the head of the Lake Fork in the "American basin" nearly east and west, there seeming to have been several injections or systems of veins which upon Mineral Mountain have intersected each other, creating thereby quite a confusion, which, if the mines situated therein turn out as expected, will necessarily provoke quite lively litigation.

The veins are in great number, and in many cases of enormous width, containing wide pay-streaks of oftentimes very rich ore. All that is needed for the success of the

mines is facile communication and cheaper transportation. The shortness of the summer season—if there be such a thing here—and the length of the winter is a serious drawback. The mines, as a rule, are between 11,000 to 13,000 feet above sea-level. Water freezes nearly every night. Snow may be expected any time after the 15th of September, and by the 1st of November the higher passes into the Animas Basin may be closed until about July 1. July, August, and September, then, are about the only months that outdoor work can be carried on, and almost daily rains during this interval call for the genius of a Tapley and the aquatic disposition of an Aleut to preserve an equable and serene frame of mind. If one attempts to cross a range of mountains, he is tripped by fallen logs or mired in the mud. If out of his tent or hut after half past 1 or 2 o'clock in the afternoon, he is drenched with rain, pelted with hail, or dredged with snow. If so unfortunate as to be caught upon a high peak about this time, he will be shocked by electricity and frightened out of his wits by singing rocks, stinging ears, fingers, and nose, lively hair and beard, loud crashes of thunder, and horribly-uncertain streams of lightning. The manifestations of induced electricity are very interesting, but very unpleasant. Every hair and every projecting member of one's body becomes a small discharging-point, and continued small discharges, prior to a great discharge of lightning from the clouds above, upon one's nose and ears and hair, are excessively annoying; one feels like a pincushion in demand. Every rock upon a peak becomes similarly electrified by induction, and, the tension becoming too great, minor discharges take place thereto, so that every sto nebegins to sing louder and louder, until finally a stream of lightning, seemingly as large as a man's waist, of solid fire, leaps down to earth, followed by a crash of thunder like the discharge of mighty artillery. One such great discharge generally is sufficient to determine the hasty flight from high peaks of aspiring mules and men, miners and donkeys.

The mines are as yet but little developed, but very extensive preparations are in progress now. Several smelters have been and are to be erected in the various districts, and, as soon as miners can begin to make their ores pay for work, the condition of things will be much improved. Capitalists are deterred from investing on account of the inaccessibility of the districts, and the owners have been too poor in ready money to open up their mines in places where they could not receive any immediate return. There can, however, be no reasonable doubt of the future of the districts mentioned, and the great immigration to that region in the spring of 1876 shows the increased confidence felt in these mines. In 1875 the population of these mountains was about 3,500. Thirteen towns have been founded, viz: Silverton, Howardsville, Eureka, and La Plata on the Animas; Mineral City, Park City, and Ouray on the Uncompahgre; Tellurum, Cottonwood Junction, and Lake City on the Lake Fork; Parratt City on the La Plata River, where veins of gold-bearing quartz have been located and an extensive auriferous bar is about to be worked; Hermosa and Old Animus City, or Elbert, on the Lower Animas River, in the Park.

Average cost of mining the ore is from $8 to $15 per ton. Cost of driving tunnel on main vein, $25 per foot. Cost of sinking a shaft in main vein, $25 to $30 a foot.

Points of supply Del Norte and Saguache, Colorado Springs and Cañon City. Freights, $160 a ton to Cañon City or Colorado Springs, 220 miles.

There is no grain and hay in market; the grass is good throughout the mountains.

No Indians within limits of the mineral belt except the Weeminuche Utes on the La Plata; the Tabequache Utes occasionally visit the mines, but they have now no claim to the land.

Mountain-sheep and bears are about the only large game, and these are becoming very scarce, having been driven away by the blasting in the mines. Grouse and ptarmigan are quite plentiful. The San Miguel and Dolores are filled with trout, and also the Lake Fork below the falls.

Saw-mills have been erected in nearly all of the districts, and lumber and shingles can be purchased at from $20 to $40 per thousand for the former, and $7 per thousand for the latter. Everywhere is abundant water for machinery of nearly any power required of pure snow water of constant and rapid flow.

ROUTES OF COMMUNICATION.

At present the San Juan mining region is reached from the last of three main lines of communication.

1st, From Cañon City, via Pleasant Valley, Puncho Pass, Cochetopa Pass, to Lake City, on the Lake Fork of the Gunnison; thence a road leads to the Animas Forks and the mines on the Animas and headwaters of the Uncompahgre.

2d, From Pueblo or Cucharas Station, via the Mosca, Abeyta, or Sangre de Christo Pass, to Del Norte, thence via the headwaters of the Rio Grande del Norte to the Animas mines; a branch road from Antelope Springs also leads over to Lake City, connecting with the first-mentioned line near the lower end of San Cristobal Lake.

3d. From Santa Fé and northward to Taos a road leads via Abiquiu and Tierra Amarilla to the Animas Park, thence a trail to the Animas mines.

From Colorado Springs the first route is joined by a road via the Ute Pass, Colorado Salt-Works, Trout Creek Pass, and the valley of the Upper Arkansas, near the mouth of Puncho Creek, after which it coincides with this first route. Also from Conejos and the southern portion of the San Luis Valley the third route may be reached by a road via El Rito and Ojo Caliente.

Annexed hereto are tables of distances by way of either of the roads except the third, which has not been surveyed throughout its length. The notes thereto attached are sufficient to enable one designing a visit to the mines to select the most convenient route. A detailed description of each is not necessary here, since they have already been described, or at least the eastern portion of them, in former reports.

The greatest interest attaches to the immediate approaches to the mines. Granting that it may be practicable to reach by rail the San Luis Valley from the east, and that it is from this direction that a railroad-route will be built, tapping the mines, the question of communication is narrowed to the practicability of attaining the mines from this valley. As far as possible, I caused profiles to be made of all approaches at present in use, or which seemed to me to offer possible routes, either for wagons or railroad, within the limits of the area assigned to me, the most important of which are hereto attached, with the grade per mile between the barometric stations computed. Although perhaps not sufficiently accurate for engineering purposes, they show the comparative value of the trails and roads surveyed, and may be sufficient data to save the expense on the part of those interested in such subjects of additional surveys for preliminary information.

Along the first mentioned of these routes it is practicable to reach by a railroad the valley of the Gunnison River via the Cochetopa Pass, north of the new wagon-road. Along the course of the road, however, between Cochetopa Creek and the Lake Fork of the Gunnison, the grades (as may be seen from the profiles) are too great for a railway. 1st. At the divide between the Cochetopa and Cebolla. 2d. Between the Cebolla and the Lake Fork of the Gunnison. South of this road, in the Gunnison drainage-area, there is no route as practicable as this. North of it the Cochetopa Cañon and the ridge to the west of it offer formidable obstacles, and a road will thereby be forced to follow practically the route surveyed by Capt. J. W. Gunnison, topographical engineer, in 1853, and reported upon by Lieut. E. G. Beckwith, Third United States Artillery, as far as to the Lake Fork of the Gunnison.

Here, in endeavoring to reach Lake City, an amount of blasting and rock-excavation along the cañon of this stream is greater than may be incurred, unless the products of the mines become so great as to justify the expense. So far it has not been considered advisable to gain, even at much less expense, good grades along the wagon-road above the narrowest part of the Lake Fork Cañon. Following Gunnison's wagon-road, however, to the Uncompahgre, although from his report much cutting, filling, and blasting will be necessary, it will be more easy to attain by rail the new mining town of Ouray, in the Uncompahgre Park, below the gorge of that stream. From the west possibly the same point may be reached by a road leaving the Utah Southern Railroad at Provo, in the Provo Cañon, or, better, perhaps, in the Sevier Valley, below Santaquin, and thence via Gunnison, Salt Creek, and the Wahsatch Pass, to the eastward. The difficulties along this route will be mainly in the plateau and cañon country of the Grand, Green, and Gunnison drainage-areas, for which see Captain Gunnison's report. South of the Wahsatch Pass there can be no rail-route from the west until south of the Grand Cañon of the Colorado. At best, then, the mines may be tapped by the northern route, if their products will ever demand it, at great expenditure of money and labor, by a round-about route through the Cochetopa or Wahsatch Pass.

From Del Norte a road may be built with comparative ease along the cañon of the Rio Grande, with a maximum grade of 80 feet to the mile, as far as to the mouth of Pole Creek, 13 miles from Baker's Park. From this point, however, to the summit of the range, the grade is on an average 300 feet to the mile; and from the summit to the Animas Valley at Howardsville the descent averages 900 feet per mile, and, near the summit, for 1½ miles the fall is 1,300 feet per mile. This being a slope of 20° is not a practicable route for wagons, although there have been many wagons over it. From Del Norte to the mouth of Pole Creek the main expense will be in bridging the Rio Grande at frequent intervals to avoid cuts, in excavation between Antelope Park along the cañon of the Rio Grande for 12 miles to the mouth of Lost Trail Creek, and again for several miles between Lost Trail and Pole Creeks, the slopes of the river being followed as nearly as practicable. For some distance above the mouth of Pole Creek a road might be built, but for ordinary running the increased expense from additional power required on increased grades, the greater cost of construction, and the want of level space above this point for depot, &c., would not, perhaps, make this advisable.

From the mouth of Pole Creek pack-animals are now, and will necessarily be, the only reliable means of transportation, unless, indeed, (and this will sooner or later be done if mining industry in this section proves a success,) a tramway, or partially counterpoised railway worked by the weights of ascending and descending freights and by stationary steam-power, be built across the continental divide at the head of

Cunningham Gulch. Such a line of railway in connection with this tramway seems to me to be, from its less probable cost and near approach to the various mining districts, to be the project most likely to be remunerative. At Antelope Park it would pass within 30 miles of the mines on the Lake Fork of the Gunnison, and would also be the outlet of the mining region about the headwaters of the Uncompahgre.

From the south the most promising route to examine for a railroad route seems to be that via the valley of the Chama to Abiquiu; thence to Cañon Largo, thence to the San Juan River, thence via its cañon and that of the Animas to Animas Park, 40 miles south from the Baker's Park mines. Above this point the Animas flows in a narrow cañon for some 11 miles from Cascade Creek, which does not seem to offer a very promising route, and the benchlike valley along the west side of the Animas can only be attained by a road with gradients of 300 feet per mile. Above the mouth of Cascade Creek practicable gradients may be secured by blasting along the sides of the Animas Cañon and the road carried into Baker's Park. Such a route at best, like the northern one, must be, from the nature of the mountains and mesas of the San Juan area, very tortuous and expensive in its construction, and, for a railroad, with steep gradients at many points.

If the Denver and Rio Grande Railway should succeed in entering the valley of the Rio Grande above Taos, a branch route to the mouth of Pole Creek would certainly be the most advantageous line to secure the freights of the mining district. If the Thirty-fifth Parallel route be ever completed, the communications with the south may, perhaps, be simplified, since the drainage lines of the San Juan River being all in approximately north and south directions, may offer practicable gradients for a branch railroad along lines not interrupted by vertical walls or deep cañons. Beyond the freights of the mining-camp of the La Plata range, and the possibility of reaching the mines of the upper Animas by way of the cañon of that stream, there does not seem to be anything to induce the construction of more than a good wagon-route along or near the southern route. In the valley of the Gunnison and Grand and Green Rivers it is different. This is one of the main possible, but at the same time one of the most difficult, of the transcontinental routes. There are here extensive agricultural areas and fields of coal, mines on both the northern and southern tributaries of the Gunnison, and prospective communication with the rich mines of Utah and Nevada. A road in this area, next to that via the Rio Grande Cañon, offers to be soonest remunerative, and would probably always be a link of through and extended communication, which the Rio Grande branch can never become.

In the immediate vicinity of the mines, and across the rim of the upper Animas Basin, the following trails and roads exist:

1st. Road via Cinnamon Gulch Pass to the Lake Fork of the Gunnison This will be extended through the cañon of the Animas from La Plata, at the forks of the Animas, to Eureka and Howardsville.

2d. From Howardsville, in Baker's Park, over the continental divide at the head of the Rio Grande to Del Norte.

3d. From the Animas Fork over head of Animas River to Mineral City, on the headwaters of the Uncompahgre.

4th. Trails east and west of Sultan Mountain to the Animas Park.

5th. Trail over south fork of Mineral Creek to the San Miguel and Dolores.

6th. Trails over Mineral and Crescent Creeks to Red Mountain Valley, on Uncompahgre waters.

Profiles are given herewith of the mountain parts of the first, second, fourth, and fifth.

Taken in connection with the fact that the gorge of the Uncompahgre below the mines may for the present be regarded as impassable, the problem of access to and egress from the mines of the Animas and Uncompahgre districts is a difficult one. Nowhere is this rim crossed by trail or road leading outward from the mountains with a grade of less than 800 feet to the mile, which means practically no wagon transportation at cheap rates. Of the existing roads, the Lake Fork route is the best, but this is too steep for free use. The cañon of the Animas offers to those districts the only possible route with good grades for wagons, and this is rock-bound; but it may be imperative if the mines are productive, even if the stationary steam-power line be put across the divide, to get an outlet by way of this cañon at the expense of blasting a road-bed in the flint-like sides of the cañon walls. In other words, the mining districts about the heads of the Animas and Uncompahgre must look for facile wagon communication to the south, or else to the northwest via the Uncompahgre gorge, which is equally rock-bound and of three times as steep gradients.

Besides the existing routes of communication for wagons, of which the Saguache and Lake City, and the Del Norte, Antelope Park, and Lake City roads only are available, it seems to me advisable on the part of the people of Cañon City and Colorado Springs to examine the following route for a wagon-road:

From the point the Puncho Pass and South Arkansas toll-road leaves Puncho Creek, the proposed line passes over the divide at the head of this stream to the Tumichi;

thence to the Los Pinos agency; thence over the head of the Los Pinos to the Cebolla; thence via the headwaters of the western tributary of this stream, effecting a junction with the Antelope Park and Lake City road near the summit of the range, and over its road-bed to Lake City. Of this route there will be required to be built 16 miles of mountain road from Puncho Creek to the Tumichi Valley, and about 20 miles of road from the Saguache and Lake City road, above the old agency, to the summit, or in all about 36 miles of new road. The rest of the links already exist, or else the country is level gravel which requires only a wagon to be drawn over it to make a road. By this route the long detour by Puncho Pass around by Saguache and the Cochetopa Pass to the old Los Pinos agency, and also that to the Lake Fork of the Gunnison, 20 miles to the north of the point aimed at, will be avoided and a direct route gained, shorter by four days' teaming from railroad communication than any existing line. There will be one steep pitch on the west side of the range at the head of the Tumichi, a quite difficult descent to the Cebolla, and considerable work in rock-blasting in the upper cañon of the Cebolla; but taking everything into consideration, it seems to me from a cursory examination that this route is at least worthy a close survey and study on the part of the business men of the two places mentioned.

Now that it is conceded that the mines of San Juan, La Plata, and Hinsdale counties are valuable, rich, and extensive, this problem of routes of communication must touch these towns, which are at present (and who wish to preserve this status) the principal points of supply, very nearly in their business relations, and make for them and for the transportation companies the prospective traffic of this rich mining and producing region an alluring prize.

All hypsometrical data collected by my party bearing upon this subject is attached hereto.

Respectfully submitted.

W. L. Marshall,
First Lieutenant of Engineers.

Lieut. G. M. Wheeler,
Corps of Engineers, in charge.

Appendix B.

PRELIMINARY REPORT UPON THE OPERATIONS OF PARTY NO. 3, CALIFORNIA SECTION, SEASON OF 1875–'76, WITH A VIEW TO DETERMINE THE FEASIBILITY OF DIVERTING THE COLORADO RIVER FOR PURPOSES OF IRRIGATION, BY LIEUTENANT ERIC BERGLAND, CORPS OF ENGINEERS.

Los Angeles, Cal., *February* 1, 1876.

Sir: I have the honor to submit the following preliminary report with regard to the operations of party No. 3, California section, Geographical Surveys West of the One hundredth Meridian, during the field season of 1875–'76:

DUTIES OF THE PARTY.

The following extract from letter of instructions will explain the object and extent of the investigations with which I was charged:

"United States Engineer Office,
"Geographical Surveys West of the 100th Meridian,
"*San Francisco, Cal., June* 10, 1875.

"Sir: You are hereby assigned to the charge of a party specially organized for the purpose of making a preliminary examination with a view to a further and more complete investigation as to the feasibility of the diversion of the Colorado River of the West from its present channel, for the purposes of irrigation. Your present survey will be confined to that portion of the river embraced between the foot of the Lower Grand Cañon and the vicinity of the Needles, the results of prior examinations made by parties of the survey under my charge during the past few years having shown the impracticability of turning the river from its present course at a point near the confluence of the Green and Grand, or between that point and the foot of the Grand Cañon, to direct its waters to portions of its western basin. The following route to and from the scene of your labors is suggested: From Los Angeles direct to Point of Rocks, in the Mohave Valley, thence to station at Black's Ranch, thence via Ivanpah to Cottonwood Island, on the Colorado. In returning, your line may leave the river near the Needles, running thence to the lower end of Coahuila Valley along the line of least profile. A reconnaissance-line duly checked by astronomical determinations and leveled barometrically will be measured, and as much mountain topography adjacent to this and other lines necessary to be traversed in the prosecution of your labors as time and means will permit, should be gathered.

"At mountain-peaks occupied, such instrumental observations will be taken as will permit of the introduction of such points into a scheme of triangulation, hereafter to be developed, reaching from the Coast Range near the latitude of Los Angeles to the ranges bordering on the Colorado after its great bend to the south. From present information, the most feasible, if not the only possible, points within the above limits at which the river could be taken from its present channel and carried over large alluvial areas are: 1st, at or near Cottonwood Island; 2d, mouth of Vegas Wash; 3d, foot of Virgin Cañon; 4th, Needles.

"If it is found practicable at either of these points to divert the entire body of the stream at any or all of them, you will cause surveys to be made sufficiently in detail to guide in the projection of the necessary constructions and to govern in the laying out of a canal, with an approximate estimate of the cost of such works, including embankments and cutting. In this connection the surrounding country should be scoured in search of the proper earth, rock, or other material requisite, and advantage of such examination should be taken to gather topography of the surrounding ridges in detail.

"The flow of the river and the character of its sediments will be determined at Camp Mohave and at the mouth of the Rio Virgen.

"Your attention should be especially directed to areas of marked depression along the route, and their geographical extent, with approaches thereto as far as practicable.

"Incidentally you will determine the points at which artificial reservoirs can be most easily constructed, taking advantage of the contour of the subdrainage basins; the more or less impermeable character of the soil underlying them; the value for agricultural purposes of arid tracts encountered if water can be had, and the probable amount that can be reclaimed; the analysis of alkaline, saline, and other deposits; the probable climatic changes to ensue; character of present vegetation; probable changes in the average total flow of the river in different seasons, &c. Any suggestions or recommendations growing from your examinations will be freely communicated. The physical obstacles of the section of territory to be traversed and visited are known to be great, and your operations may be materially modified and restricted thereby.

* * * * * * *

"Very respectfully, yours,

"GEO. M. WHEELER,
"*Lieutenant of Engineers, in charge.*

"Lieut. ERIC BERGLAND,
"*Corps of Engineers.*"

ORGANIZATION.

The party was organized at Rendezvous Camp, Los Angeles, Cal., and consisted of myself as executive officer and field-astronomer, 1 chief topographer, 1 assistant topographer, 1 geologist, 1 meteorologist, 1 odometer-recorder, 3 packers, 1 cook, a guide, and 3 enlisted men belonging to Company G, Twelfth Infantry; making, in all, 14 men. The means of transportation were 28 pack-mules and 1 bell-mare.

DESCRIPTION OF THE ROUTE.

The party left Rendezvous Camp on the 21st of June, and reached Martin's Ranch, at the mouth of the Cajon Pass, on the 29th of June. At this place a side-party was detached to make the ascent of Cucamonga Peak, and one of the enlisted men was sent by stage to Camp Mohave with barometer and psychrometer, to take observations during the summer, to which might be referred the observations taken on the route.

The march to this place had been necessarily slow, as the mules were nearly all wild and unbroken when the party started, on account of which much time was lost in loading and unloading the packs, and keeping the animals on the road after the train started from camp each morning.

From Martin's the route was through the Cajon Pass, over a divide of 4,487 feet altitude, thence across a portion of the Mohave Desert to the Mohave River, at Lane's Upper Crossing. The slope is gradual from the divide to the river, a distance of 18 miles. This is a barren waste, without wood, water, or grass. The only vegetation seen was sage-brush, stink-weed, a few juniper-bushes, and several varieties of the cactus family.

The yucca trees, which are found here in great numbers, obtain a height of 30 to 40 feet, and present the appearance of a magnificent forest. Rabbits, jack-rabbits, and field-rats were the only animals seen; an occasional bird; but lizards and horned toads were noted numerously. The soil consists mostly of coarse gravel, but could be made productive if it were possible to irrigate it.

The river at Lane's Crossing was about 100 feet wide, with a maximum depth of 3 feet. A considerable volume of water flows through this portion of the river at all seasons, all of which disappears in the sand a few miles below.

From this point the route followed the river to Point of Rocks Station. My instructions were to proceed north from this place as far as Black's Ranch, and thence east-

wardly to Ivanpah. From the appearance of the country already traversed, and from information gathered along the route, I concluded that the attempt would be hazardous in the extreme. But little rain had fallen during the previous ten months throughout all that section of country. Springs, which formerly had never failed, were found dry, and no grass or other feed for the animals could be obtained if we left the river; hence, I concluded to follow the course of the river as far as the Saline Flats of the Mohave, called Soda Lake by Lieutenant Whipple. This latter place was reached on the morning of July 13.

The route to the Saline Flats of the Mohave kept near the bed of the river, in which running water is seen at but few places, and in diminishing quantity as one proceeds toward Soda Lake Spring. Water can be obtained by digging a few feet in the sandy bed of the river at almost any place. Vegetation occurs at points along the river where the water comes near the surface, and at several points along the route, as Point of Rocks, Cottonwood Station, and near old Camp Cady. Extensive groves of cottonwood and mesquite trees are found. Grass was scarce along the river on account of the great number of sheep which had lately passed over that route on their way to Arizona.

Between Grapevine Station and forks of the road, the road crossed the bed of a dry lake or basin. The bed is clay, baked hard and dry, and perfectly smooth. Not a particle of vegetation is seen, not even sage-brush. It is about 2 miles wide and 4 miles long. During the rainy season, water accumulates here to a depth of a few inches, the clay becomes soft, and the road is impassable for wagons and animals.

The heat during the day kept on increasing as we descended the valley, the thermometer indicating over 100° in the shade nearly every day. The nights were generally cool, at one time the minimum temperature being as low as 44°. At Soda Lake Spring, however, no respite from the heat was obtained at night. The hot, dry wind coming from the south was almost suffocating, removing the moisture rapidly from the body, thus necessitating a great consumption of water to keep up the supply. The water here is obtained from a spring from which flows a considerable stream, clear and limpid, but strongly alkaline, and nauseating when drunk in large quantities. The Saline Flats of the Mohave constitute a basin about 20 miles long, with an average width of nearly 10 miles. The surface is composed of a white crust of saline and alkaline material deposited from the evaporated water. In the summer months nearly the whole basin is dry, but after heavy rains during the winter the surface is covered with water which is too brackish for use by animals or men.

Splendid mirages were seen here which gave the distant portions of the basin the appearance of a large lake. The illusion is perfect, and tales are told of weary and thirsty travelers who have hurried on to quench their thirst, only to be disappointed and meet a horrible death.

The drainage of the basin is toward the north, and the supposition is that it is connected with Death Valley, but this surmise has not yet been proved to be a fact.

From Soda Lake Spring to Cottonwood Island on the Colorado River, the route is northeastwardly after passing around the north end of the basin, over a range of mountains to Ivanpah, a small mining town, which contains one stamp-mill and a smelting-furnace; thence eastwardly across the dry bed of a basin without outlet, of considerable extent, over the summits of the Providence range, then down a gradual slope to the Colorado River at Cottonwood Island.

The route to Ivanpah is a trail, very heavy and sandy in some places, but passable for wagons with light loads. From Ivanpah to the summit of the river range there is an Indian trail practicable for riding and pack animals. From the summit to the river there is a gradual slope, the trail which follows the bed of the wash being practicable for wagons.

The only water found between Soda Lake Spring and Ivanpah was at Hallovan Springs, Camp 17, and France's Spring, Camp 18. At the former the supply was limited. Between Ivanpah and Cottonwood Island no water was found except at Crossman Spring, Camp 20.

At Ivanpah we were assured that an abundance of water would be found in wells on the east side of the basin; but on arriving there the wells were found dry, and it became necessary to push on to the spring. There but a small quantity of water was found, which was soon exhausted by the animals. The mud and decayed vegetable matter which nearly filled the spring were then removed, but the water trickled in so slowly during the night that there was not enough for the animals in the morning. But little grass was found on this part of the route. "Gallete" grass, very coarse and dry, was found in considerable abundance east of the basin, near Ivanpah; the latter place obtains its supply of grass here. Near the summits of the ranges some bunch-grass was found and a better quality of "gallete," but generally the grass was too far from the water to be of avail. Hallovan Springs was an exception to this rule; but here the water gave out, so we could not take advantage of the excellent bunch-grass found near this place. From the summit of the river-range we obtained the first view of the Colorado River. From this point it lay before us like a silver band, sparkling in

the sunlight, a most pleasant sight, as it gave assurance of abundance of water for a time at least.

Cottonwood Island, with its majestic cottonwood trees and rich vegetation, afforded a pleasant relief to the eye, after having seen nothing but black, barren rocks and parched, sandy valleys since leaving old Camp Cady.

The island, which is 5 miles long and less than half a mile wide, is occupied by a number of Pah-Ute Indians. Others of the same tribe have rancherias along the west bank of the river. They raise a few vegetables, a little corn, melons, and wheat; but their principal food is the mesquite bean. They had no supplies to sell to our party, as the products of their small gardens are consumed as fast as they ripen. They make no efforts to catch fish, but occasionally shoot a mountain-sheep, and hunt regularly for a species of large lizard and the field-rat. They visited our camp daily, begging for bread and tobacco, but otherwise did not molest us, nor did they show any propensity for stealing.

At this place a party was sent to Camp Mohave for supplies to replenish our nearly exhausted stores, and after a few days' rest we proceeded up the river to Stone's Ferry.

The trail followed the river closely as far as El Dorado Mill. From thence a wide detour had to be made to get around the Black Cañon, and we reached the river again at the mouth of Las Vegas Wash. From this point another detour was made to avoid the Bowlder Cañon. The route hence was up the Callville Wash, over the divide, and down a gradual descent to the Virgen River, which was reached about 15 miles from its mouth; thence down the Virgen to the Colorado at Stone's Ferry, which point was reached on the evening of August 4. This part of the route was almost entirely destitute of vegetation; even the camps on the river afforded no grass for the animals. At Bitter Spring, Camp 28, some salt grass was found, but it was poor feed for the animals, and harmed more than it benefited them. The water at Bitter Springs is decidedly alkaline and unpleasant to the taste. Signs of water were observed near the summit of the Callville Wash, and some green grass was found in the immediate vicinity. The water of the Virgen was unfit for use by men or animals. It was intensely saline, its color brick-red, and surface covered with floating slime of the same color.

The trail from Cottonwood Island to Eldorado Mill is very rough, in some places precipitous and dangerous, entirely impracticable for wagons. Thence to mouth of Las Vegas Wash the trail is not so difficult, and nearly all of it could be traveled by lightly-loaded wagons. Thence to Stone's Ferry the route is practicable for wagons. Callville is entirely deserted; the wood-work has been removed from all of the houses, and nothing but crumbling walls indicate the site of the city at the "head of navigation."

In the vicinity of Stone's Ferry and along the Virgen are found extensive deposits of rock-salt, and near the ferry there is a natural curiosity called the "salt well." This is a hole in the mesa, nearly circular, with steep walls, partly filled with a strong solution of salt. The greatest depth of water was found by sounding to be 96 feet, the diameter of the water-surface 118 feet, high-water mark above present surface 4 feet, and surface of water below crest of well 43 feet. The surface of the water in the well was found to be 3.9 feet above the surface of the river at the nearest point.

A considerable quantity of rock-salt is obtained in this vicinity, which is used in the reduction of ores both in Nevada and Arizona.

At Stone's Ferry we remained until the 14th of August. The time was occupied in taking soundings and current-observations. A description of the method used and results obtained will follow.

From Stone's Ferry, after crossing the river, we followed the road through a wash which heads in the almost insensible divide leading to the Sacramento Valley; then along this valley to Chloride; from this point, through Union Pass, to Hardyville and Camp Mohave. The first march, from the river to Mountain Spring, is a long stretch of over 40 miles without water. The ascent from the river is gradual and at the rate of about 80 feet to the mile. The first 10 miles is through a narrow wash, destitute of vegetation, then the wash gradually widens into a valley of magnificent proportions, bounded on the east by the Sacramento Mountains, and on the west by the river range. This valley was covered with different kinds of grasses—in the northern part principally coarse gallete, but farther south more nutritious grass was found in quantities sufficient to feed thousands of cattle, which is not available because water cannot be procured. Attempts have been made to dig wells in this valley, but no water has been obtained except in the vicinity of the springs near the summit of the valley. The spring at Nobman's Ranch furnishes water for about two hundred head of cattle. At Chloride we obtained good water from a well about 40 feet deep. The town was almost deserted, but half a dozen men living there. The mines were not worked, and the smelting-furnace stood idle at the time of our visit. There is a good wagon-road all the way from Stone's Ferry to Camp Mohave, a toll-road having been built through Union Pass.

The weather was pleasant and temperature moderate in the Sacramento Valley, but as soon as we crossed the summit of the river range we began to experience the dry atmosphere and excessive heat that had been felt previously in the valley of the Colo-

U.S. GEOGRAPHICAL SURVEYS WEST OF THE 100th MERIDIAN.

PARTS OF SOUTHERN AND SOUTHEASTERN CALIFORNIA, S.E. NEVADA AND N.W. ARIZONA.

EXPEDITION OF 1875, under the command of

1st Lieut. GEO. M. WHEELER, Corps of Engrs. U.S. Army.

BY ORDER OF THE HONORABLE SECRETARY OF WAR

UNDER THE DIRECTION OF BRIG GEN A A HUMPHREYS, CHIEF OF ENGINEERS, U S ARMY.

rado. Camp Mohave was reached August 20, and here we remained two weeks, taking soundings and current-observations.

On September 5 we left Camp Mohave, moving down the east bank of the river to Liverpool Landing, where a crossing was effected by means of a small ferry-boat. Thence down the west bank to a point opposite Ehrenberg, where supplies were obtained for the return trip. The first part of the route was through the Mohave Valley, as it is called in Lieutenant Ives's report, probably because it was then, as it is now, occupied by the Mohave Indians. The bottom-land fit for cultivation is on the east side of the river, and all is subject to overflow when the river is unusually high, which happens whenever there is a heavy fall of snow along the upper portion of the river.

The Mohaves cultivate small patches of ground, raising vegetables, melons, corn, and wheat. They are more industrious and provident than the Pah-Utes, and usually lay in a supply for the winter, and have enough surplus to supply the post with melons and vegetables during the summer. The valley ends at the Needles, where the mountains close in on both sides, forming a narrow cañon. Below this cañon is the Chem-e-hue-vis Valley, occupied by a portion of the Chem-e-hue-vis Indians. Thence down to Ehrenberg, the valley or bottom-land is of varying width, most of it being on the east side of the river. A few miles above Ehrenberg the river crosses over to the east side, leaving a wide bottom-land on the west side opposite this place. These bottom-lands, formed from the deposits of the river, have rich soil, and, with irrigation, could be made very productive, if the river could be confined to a constant channel and prevented from overflowing the bottom-lands. Along the river there is a rich growth of trees, principally cottonwood, and here the fuel is obtained for the river-steamers.

The road from Camp Mohave to the Needles is good. Thence, over the Needle Range, the trail along the river is in places very difficult, and practicable only for pack-animals. After crossing the river at Liverpool Landing the trail leaves the river to the left, passing around Mount Whipple, and, after crossing the Monument Range, strikes the river again nearly opposite the Indian reservation at old Camp Colorado. Thence to Ehrenberg the trail follows the river, part of it being difficult and fatiguing, as it continually crossed deep washes. After crossing the river, grass was scarce, the best supply being found, us usual, where the water was not accessible.

From Ehrenberg we followed the old stage-road to Chuckawalla, thence to Dos Palmas, Los Torros, Agua Caliente, Whitewater, through the San Gorgonio Pass to San Bernardino, and thence back to Los Angeles, which point was reached October 4.

After crossing the river-bottom opposite Ehrenberg the road ascends to the first summit, which is 934 feet above sea-level. West of Chuckawalla we cross another divide at an altitude of 2,689 feet; thence the slope is downward to Dos Palmas, beyond which place the road crosses a portion of the low basin below sea-level. From thence the ascent is slow and gradual to the summit of San Gorgonio Pass, which has an altitude of 2,743 feet. Westward from this point there is a gradual descent to Los Angeles. The road from Ehrenberg west as far as Los Torros is tolerably good. From the latter place to Agua Caliente it is very sandy and difficult for wagons. This portion of the Coahuila Valley is covered with immense sand-hills, some of which seem to be permanent, as large-sized mesquite and other brush grow on their summits. Others are constantly shifting their position, according to the direction of the prevailing winds. From Agua Caliente to San Bernardino the road is good and the grades easy.

The stages having been taken off this route and transferred to the Mohave River route, most of the stations had been abandoned, hence we found it difficult to obtain water and feed for the animals at several points. At Ehrenberg I was assured that water of good quality and sufficient quantity would be found at Mule Spring Station, but on arriving there no trace of the well could be discovered, and not a drop of water obtained. A cloud-burst had occurred a few days previous to our arrival, the water from which had formed a new wash over the site of the well, and it had been completely filled up and obliterated by the sand and gravel washed down from the hills. The sand in the bottom of the wash was still moist, which gave us hopes that water might be obtained by digging, but our efforts were in vain, and we were forced to start for Chuckawalla, though uncertain if water could be procured there. After a long march of over 40 miles the latter place was reached late in the evening, and, fortunately, water was obtained here. Some of my men suffered (mentally, at least) considerably from thirst before this place was reached, as the contents of the canteens had given out long before we reached it, and had we not obtained water here the consequences might have been serious. The springs of Chuckawalla had been filled up by the washing from a cloud-burst, also, but a couple of men had gone there a few days previously to open the station, and they had removed the sand and gravel from the springs. The water here is quite good, it having but a slight alkali taste. At Dos Palmas the water is very alkaline and salty. Quite a stream issues from the ground at this place. At Los Torros the water is good, and there is a plentiful supply of it. At Agua Caliente the water is warm and sulphury; its temperature is about 100°. On cooling, it loses most of its sulphury odor and taste. White River rises in the San Ber-

nardino Range, flows across the valley, and disappears in the sand near the base of the San Jacinto Peak.

Green "gallete" grass was found in the washes near Mule Spring Station. These washes also contain a plentiful supply of mesquite trees and a few willows. At Dos Palmas there is a little salt grass. Los Torros and Martinez are fertile spots in the desert. Here the water rises near the surface and the soil remains moist the whole year, hence vegetation flourishes and the ground is eminently fit for cultivation. At these places and at Agua Caliente are found numerous Indian rancherias, occupied by the Coahuila Indians. These Indians cultivate small garden-plats and raise some grain and vegetables.

The temperature was high when we passed through the valley, and in the lower portions of it the heat was excessive, being about the same as had been experienced on the Colorado River, although it was now the latter part of September. The atmosphere was also very dry, and the same hot, desiccating winds were encountered here. Portions of this valley bear unmistakable evidence of having been covered with water. The beach-line is very distinct just before reaching Dos Palmas, and also in the vicinity of Los Torros. Great quantities of shells are seen in a good state of preservation near this beach-line, which would seem to indicate that the time the lake existed was not very remote.

After attaining the first summit from Ehrenberg a valley of considerable extent is seen to the west, which apparently has no outlet. This basin is not as low as that of the Coahuila Valley. (On passing this summit on my second trip I ascended a high peak near the road. The view obtained from that point leads me to believe that the valley referred to has a drainage to the river through a wide wash several miles above the Lagura.)

SECOND EXPEDITION.

By letter of instructions dated United States Engineer Office, Geographical Surveys West of the One Hundredth Meridian, Washington, D. C., January 19, 1876, I was directed to organize a party and proceed to Ehrenberg, on the Colorado River, thence down the western bank to the boundary, for the purpose of continuing the investigation as to the feasibility of the diversion of the river for purposes of irrigation, and also to determine, if practicable, the approximate area of the depression below the level of the sea. The middle route, via Temecula, was specified as the inward route from Fort Yuma to Los Angeles.

ORGANIZATION.

The party was organized as follows: 1 executive officer and field astronomer; 1 topographer; 1 assistant topographer; 1 meteorologist; 1 odometer recorder; 2 packers; 1 cook; 1 teamster; 2 enlisted men. Total, 11.

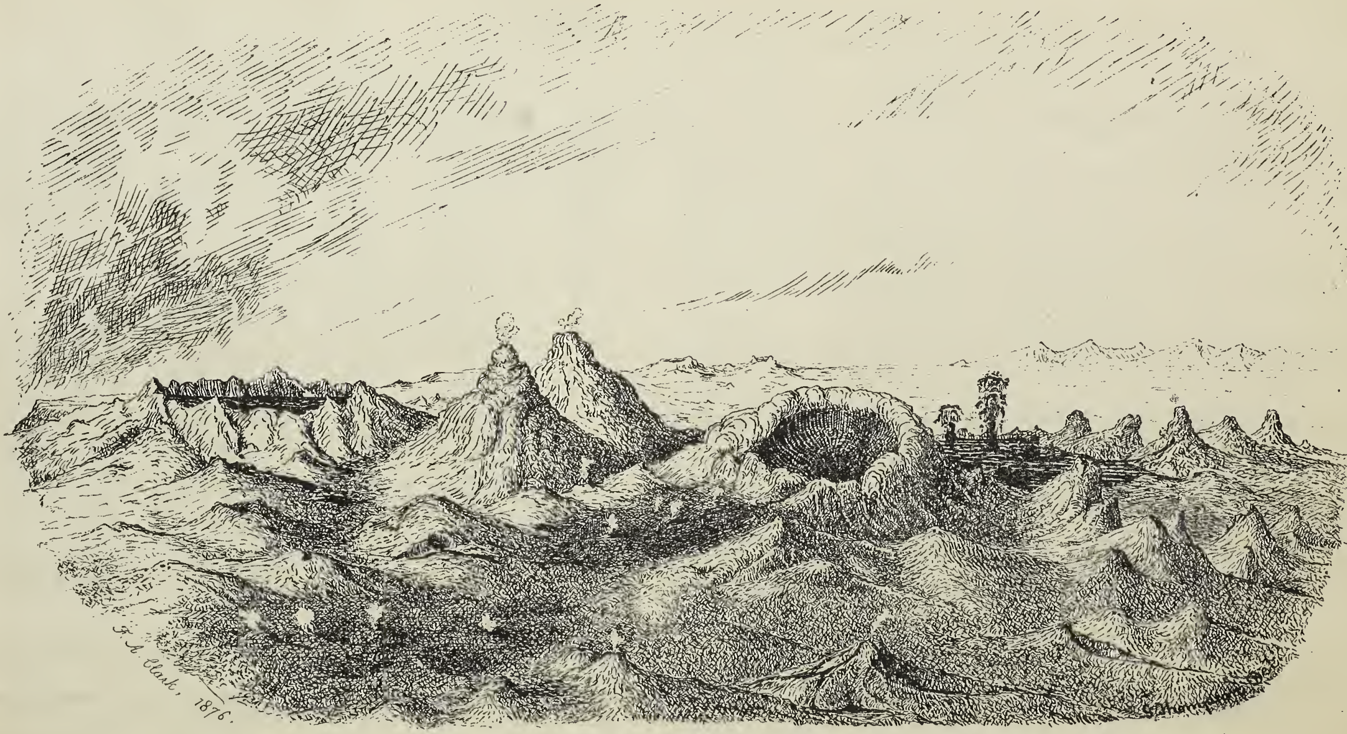
Means of transportation were: 10 riding-mules; 7 pack-mules; 3 extra mules; 6 team-mules. Total, 26.

One enlisted man, Sergeant Eugene Farnham, Company G, Twelfth Infantry, was left at Los Angeles as barometer observer during my absence. I will take occasion to remark here that he performed his specified duties to my entire satisfaction, recording the observations carefully and accurately.

DESCRIPTION OF ROUTE.

From Los Angeles City to Ehrenberg, Camp 14.—The party left Los Angeles February 13, and reached the Colorado River opposite Ehrenberg, Ariz., March 3. The outward route was the same as the inward route of last trip. Several changes had taken place since we previously passed over it. The Southern Pacific Railroad was now finished as far as Whitewater Station, and the grading completed to a point opposite Indian Wells. Two stage-lines were running from the terminus of the railroad to Ehrenberg, and thence through Arizona and New Mexico. Consequently the stations had been fitted up and wells and springs cleaned out, so that the supply of water was abundant. A few new wells had been dug and stations established by the new stage-line, (Wells's Express Company,) as at a point about half-way between Torros and Dos Palmas, and another 6 miles east of Mule Spring Station. A well was being dug on the Chuckawalla Bench, between Cañon Springs and Chuckawalla, with but little chance of striking water.

The country appeared rather more sterile and forbidding than before, as the mesquite trees had lost their leaves, and not a spear of green grass was to be seen between Whitewater and Ehrenberg. The temperature was, however, tolerably cool during day, and the nights were sometimes quite cold. Ice formed during the night at Whitewater, Chuckawalla, and one night at Ehrenberg. The day we went from Cañon Springs to Chuckawalla we had a drizzling rain, and this was accompanied by a cold, piercing wind on the high mesa near the divide. At Ehrenberg the river was found to be about 2 feet lower than it was at the time of our first visit. A long sand-bar was exposed between the ferry-landings, which rendered it necessary to tow the ferry-boat half a mile up stream before a crossing could be effected.



MUD VOLCANOS,
South-Colorado Desert.

From Ehrenberg to Fort Yuma, Camp 19.—There being no wagon-road near the western bank of the river, I was obliged to cross my wagon and team, and send it down the river on the eastern side via Tyson's Wells and Gila City. The party with the pack-train proceeded down the river, keeping as close to the bank as the conformation of the country would permit. We left Ehrenberg on the 8th day of March, and reached Fort Yuma March 12. Camp 15 was on the river, near an Indian rancheria; Camp 16, at Panchos Ranch, a deserted Mexican hut; Camp 17, at Round Hill, (Ives,) just below Light-house Rock; Camp 18, at Picacho Mill, in the Cane-brake Cañon, (Ives.) The route from Camp 14 to Camp 15 is mostly a wood road; from Camp 15 to Camp 16 a trail impracticable for wagons, but not difficult for pack-animals. Several detours have to be made to avoid deep lagunas, and the trail leads over a long sand-flat in the river-bottom. From Camp 16 to Camp 17 the trail is mostly in river-bottom, but at times on mesa, where it crosses several deep, dry washes. At time of high water the trail in the river-bottom cannot be used at all; travelers then have to take the trail along the mesa and over projecting spurs of the mountains, which is very steep and difficult in several places. Near Camp 17 was found the only patch of grass along the river.

From Camp 17 *to Camp* 18.—Trail near the river principally on the mesa, crossing frequently deep washes with high, steep sides. Camped at the Mill. This mill, which has five stamps, was standing idle, and had a sheriff's writ of attachment nailed to the door. The ore found at the mill is said to yield $17 per ton. It is friable and easy to crush. The mines are located up a wash near the Chimney Peak. A good wagon-road leads from the mines to the mill. No wood, except mesquite, in the vicinity.

Camp 18 *to Fort Yuma, Cal.*—At the Mill the trail leaves the river, and follows the road to the mines until the vicinity of Chimney Peak is reached, when it leaves the wash and ascends the mesa. This has a gentle slope up to an altitude of over 700 feet. Near the summit a number of Mexicans were working placer-diggings. Water being scarce, they used the dry process for separating the gold. The yield is small, but is enough to pay industrious men well.

The descent to the river-bottom on the south side of the divide is through a narrow wash or cañon, whose walls are almost perpendicular, and sometimes overhanging, and in some places not more than 6 or 8 feet apart, and over 50 feet high. The side washes are deep, narrow fissures, too narrow for the passage of a pack-mule. The river-bottom is several miles wide, and the soil of the same character as that observed above Ehrenberg. It is covered with mesquite trees and arrow-weeds; nearer the river, however, are found a number of large cottonwood trees and willows.

At Fort Yuma, the commanding officer, Major Mizner, Twelfth Infantry, kindly allowed me to use a vacant building near the ferry for the shelter of my party, and during my stay at the post he and the other officers willingly gave me all the assistance I required, as also did Captain Bradley, assistant quartermaster, in charge of Yuma quartermaster depot.

During our stay here, current-observations were made and soundings taken, to determine the discharge of the river. At this time the river had reached its lowest stage; no rise from melting snow in the upper portions of the Colorado or Gila Rivers had yet taken place, hence the discharge shows the minimum amount which the two rivers combined will furnish. Experiments on evaporation were also made here.

April 2 the party left Fort Yuma, following the road along the west bank of the river to Algodon Station, just below the boundary-line. At this place the party was divided.

A portion, with the pack-train, went in a southerly direction to visit the hot springs and mud volcanoes in the vicinity of Mount Purdy, while the remainder, with the wagon, followed the stage-road. The parties were to meet at New River or Indian Well Station.

Algodon, via Mount Purdy, to Mud Volcanoes.—The road taken by the side party leaves the main road a short distance below Algodon, when it leaves the river-bottom. The direction thence is southwesterly toward Mount Purdy. It crosses several of the channels of New River, which at this time were entirely dry. Water was found in three places along route, contained in natural reservoirs, these being depressions in the dry channels. The last water occurs about ten miles from Mount Purdy. Here the kegs were filled, and a dry camp made near the base of this peak. Thence the distance to the volcanoes is about 5 miles.

The country from Algodon to Mount Purdy is nearly level; the portion near the river is thickly covered with mesquite trees and willows. As the distance from the river increases the vegetation becomes more sparse, until, within 5 or 6 miles of Mount Purdy, the plain is entirely destitute of it. The ground here is covered with a crust of salt for many miles in extent. At the base of Mount Purdy there is a stream of running water, which is intensely salt. This flows toward the northwest, or in the direction of New River Station. Mount Purdy is the crater of an extinct volcano. The crest is about 600 feet above the level of the plain at its base, and the interior of the crater is filled up to within about 100 feet below the crest. From the summit a good view is obtained of the surrounding country except toward the west, where the Cocopah range

obstructs the view. From Mount Purdy to Mud Volcanoes the direction is southeast, the distance about 10 miles. Trail is good most of the way, the only difficult place being the crossing of a salt creek with marshy banks. After crossing this creek the trail is on a hard, gravelly mesa until it nears the mud volcanoes. The ground within an area of 200 by 500 yards is covered with large and small craters formed from the mud which has been thrown up into conical mounds. These mounds vary in height from 3 to 6 feet, and in diameter, at the base, from 5 to 20 feet. Some have large open craters, within which the hot mud can be seen constantly boiling and bubbling. At short intervals columns of mud are thrown up to the height of 4 to 6 feet, but no regularity in the pulsations could be discovered, nor did they occur at the same instant in the different craters. The smaller cones had small openings at the apex, from which issued sulphurous vapor with a hissing noise.* The center of this area was occupied by a lake of boiling mud, all parts of whose surface were constantly agitated, and from which the mud was occasionally thrown up several feet in height. A small pond of clear water is situated within the area covered by the mud volcanoes. The temperature of the water is 100°. A small spring of clear water was found near the mud lake with a temperature of 199°. A large pond or lake of clear water is situated east of the mud lake and at a lower level. The water of this lake has a temperature of about 96°, and also has a strong taste of alum. The temperature of the boiling mud was found to be 210°, and that of the vapor issuing from the smaller orifices was about the same. A large mound situated some 200 yards to the southeast of the mud lake appears to have been thrown up by this volcanic action. The crust is composed principally of sulphur, much of which occurs as pure crystals. It is not in action now, but the hollow sound heard when walking over it seems to indicate that the mound is a hardened crust with a partly-filled interior which possibly communicates with the active volcanoes. The liquid mud is black, but on drying it becomes gray, and is very pungent to the taste. A quantity of this mud was collected for analysis, and bottles of water from the lake, pond, and hot spring were obtained.

The surface of the ground between Mount Purdy and the mud volcanoes is dotted over with extinct solfataras, with here and there one from which hot vapor issues. A few were also observed east of Mount Purdy. Indians living in the vicinity and old white settlers say that at night flame is seen issuing from these volcanoes, and sometimes high columns of steam. This usually occurs during an overflow of the river.

From Mud Volcanoes to Indian Wells.—After visiting the volcanoes the side party returned to camp, and started the following day for New River station. The route follows closely one of the New River channels. These channels can be detected by the rich growth of mesquite trees, which grow in the bed and along the banks. The soil is very rich, and after an overflow the grass springs up and matures rapidly. When we passed these flows were entirely dry and destitute of grass, there having been no overflow for several years.

At New River Station water is obtained from a well in the bed of New River; water brackish and disagreeable to the taste. Between New River and Indian Wells Station we followed the stage-road, which here passes over an almost level plain, when we had the phenomena of *mirage* the whole day, the plain appearing as an immense lake of water. At Indian Wells we were joined by the main party, who followed the road. Here also we experienced one of the most disagreeable features of this desert country. Shortly after our arrival in camp it commenced to blow. The winds increased in force, and soon a hurricane was blowing. This wind carried with it clouds of fine sand, which penetrated eyes, ears, and nostrils, as well as instruments and provisions. Traveling or work of any kind was out of the question. There was nothing to do but to wait until the wind subsided. After three days of impatient waiting there was a lull in the storm, and during the night the clouds of sand settled so that we could see some distance in front of us. During this storm high mounds of sand had accumulated around the houses at the station whenever the smallest obstruction permitted a slight lodgment. The wood-pile disappeared entirely, being covered over with some 3 feet of sand. The effect of these sand-storms seems to be to cover the plain to the west of Indian Wells with sand-dunes. A few years ago the sand had not reached Indian Wells, but the station is now entirely surrounded with sand-hills of varying height.

From Indian Wells Station I ascended Signal Mountain. The aneroid indicated an altitude of 2,300 feet at the summit. Here an extensive and extended view was obtained of the greater portion of the Colorado Desert, Lake Maquata (Stretch,) a salt lake on the west side ef the Cocopah Range was seen to be almost dry. The water lines on both sides of the range could be plainly discovered, and the cones of the mud volcanoes in the Coahuila Valley were seen with the telescope. The northwestern end of the sand ridge lies nearly due north from this position. The eastern end is near Algodon Station. The course of New River could be traced, as it bends to the northwest of the station, and continues on into the desert. There is no grass or other vegetation on the mountain except a few bunches of "palo verde" near the summit. No water

* NOTE.—On approaching these cones the rumbling noise within could be distinctly heard.

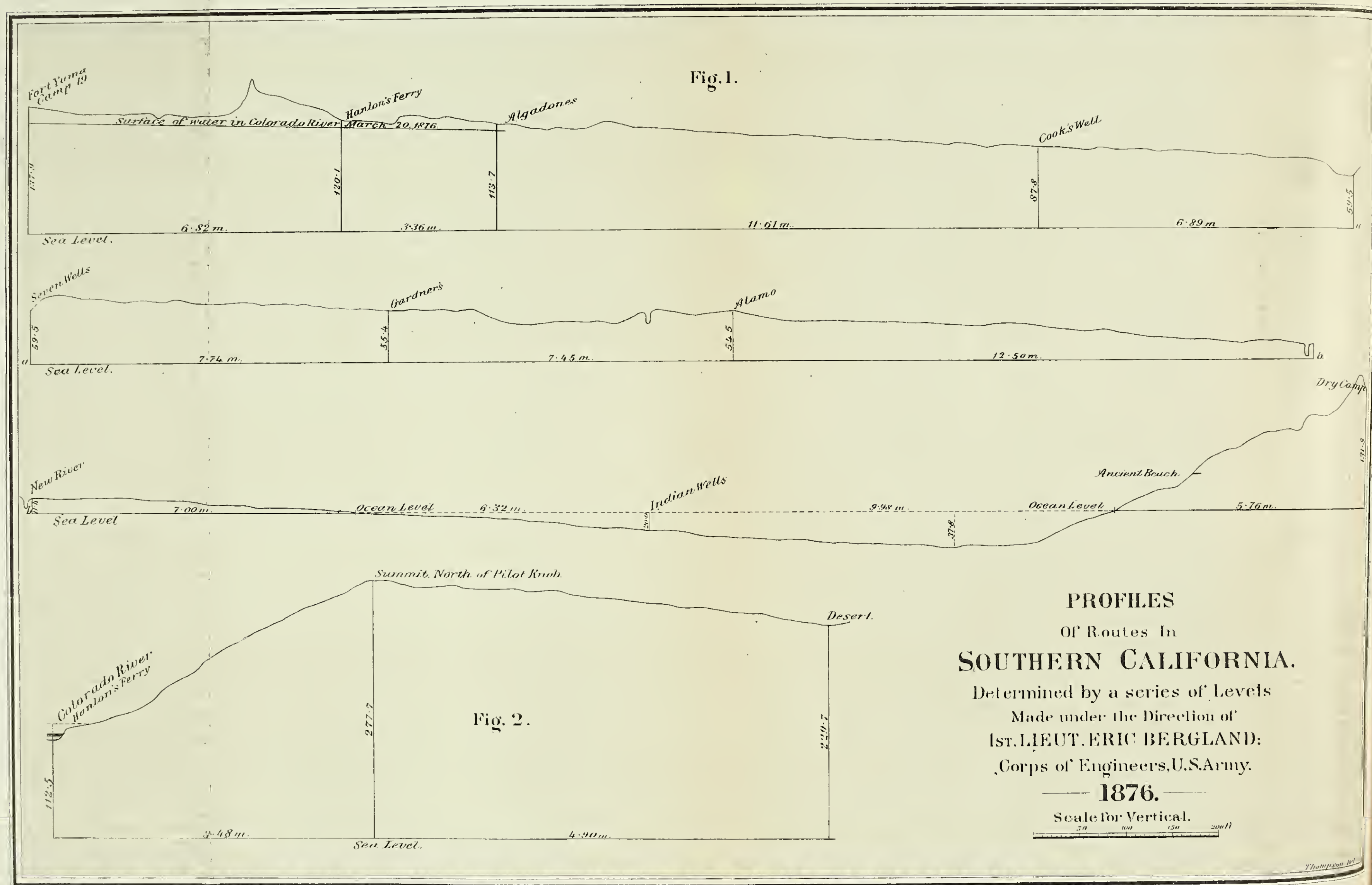


Fig. 1.
Fort Yuma Camp 19
Hanlon's Ferry
Surface of water in Colorado River March 20, 1876.
Algadones
Cook's Well
120·1
113·7
87·8
59·5
6·82 m.
3·36 m.
11·61 m.
6·89 m
Sea Level.
Seven Wells
Gardner's
Alamo
59·5
35·4
54·5
7·74 m.
7·45 m.
12·50 m.
Sea Level.
Dry Camp
New River
Ancient Beach
Indian Wells
Ocean Level
Ocean Level
7·00 m.
6·32 m.
9·98 m.
5·76 m.
Sea Level
Summit North of Pilot Knob.
Desert.
Colorado River Hanlon's Ferry
Fig. 2.
277·7
112·5
3·48 m.
4·90 m.
Sea Level.
PROFILES
Of Routes In
SOUTHERN CALIFORNIA.
Determined by a series of Levels
Made under the Direction of
1st. LIEUT. ERIC BERGLAND:
Corps of Engineers, U.S. Army.
1876.
Scale for Vertical.
Thompson del.

was discovered in the vicinity or on the mountain. Galleto grass in considerable abundance grows on the plain at its foot.

From Indian Wells, Cal., to Los Angeles, Cal.—The party left Indian Wells on the 14th of April, and made a dry camp near Sacket's Well. This well has been entirely obliterated, and no water is found between Indian Wells and Carizo Creek. From this latter place the route leads through Vallecito, San Felipe, Warner's Valley, Oak Grove, Bergman's, Temecula, Laguna Grande, Temeacal, down the Santa Ana Cañon to Anaheim, and thence to Los Angeles, which place was reached on the 7th day of May. The road is tolerably good, except over the Carizo Creek Hill, Vallecito Hill, and through Vallecito Cañon. From Indian Wells to Vallecito it is quite sandy. A little salt grass was found at Vallecito, but at San Felipe and westward good grass for the animals was obtained. Some of these valleys were very beautiful, being covered with wild flowers of different hues, which, mingling with the rich green of the flourishing grasses, made a pleasing picture for the eye. Water in abundance was found in these valleys, and of good quality, except at Vallecito. The passage through the Santa Ana Cañon was rather difficult, as the river had to be crossed seven times, and the stream was rapid, and bottom, in places, composed of dangerous quicksand.

THE DIVERSION OF THE RIVER.

This subject will now be considered. The Colorado River from the mouth of the Grand Cañon down to Chem-e-hue-vis Valley, just below the Needles, may be said to flow through a cañon which occasionally widens into a narrow valley, as at the mouth of the Virgen, Las Vegas Wash, Cottonwood Island, and the valley from Hardyville to the Needles. These valleys are separated by spurs and ranges through which the river has cut its way, forming the Bowlder, Black, and Pyramid (Ives) Cañons, and the cañon of the Needles.

Below the Needles we have the Chem-e-hue-vis Valley, which is again separated from the Great Colorado Valley (Ives) by the Monument Range.

The ranges between which the river flows are nearly 4,000 feet high at the great bend, the divide on the west side opposite Cottonwood Island being 3,900 feet, and that on the east side at Union Pass 3,800 feet; while the summit of the Sacramento Valley near Chloride is about 4,100 feet above sea-level. As we proceed southward the river ranges become sensibly lower. Thus the highest altitude of the trail over the Monument Range is 2,300 feet, and the summit of the river range on the west side opposite Ehrenberg is 934 feet. Beyond the ranges which inclose the river are other higher ranges, with valleys between, whose altitudes are greater than that of the river.

These topographical features can be plainly seen by referring to the map and profiles of the route. This being the case, it is evident that the river cannot be diverted from its present bed between the mouth of the Grand Cañon and the head of the great Colorado Valley.

In this valley there is a large area which could be made productive if irrigation were practicable. An effort in that direction has been made at the Indian reservation at old Camp Colorado, on the east bank of the river, above La Paz. Here an irrigating-canal several miles long has been tried. From the information I received about it (I did not have an opportunity to inspect it) I learned that the soil was so porous and unstable that the banks were constantly undermined, causing them to cave in and fill the canal. After repeated trials the projector had concluded to flume the entire canal, which can only be done at great cost where lumber is scarce and prices high. Even if irrigation were practicable, it would be necessary to build levees to prevent the river from overflowing the bottom-lands and destroying the irrigating-canals and ditches The Great Colorado Valley is terminated at the south by the Chocolate Range, through which the river passes, and emerges from the Purple Hill Pass into the wide valley, which extends to its mouth.

Below the Purple Hills there are no formidable mountain ranges on the west side of the river, except a short detached range, called the Cargo Muchacho, and Pilot Knob. The divide between these mountains is about 278 feet, while the altitude of the water-surface at Fort Yuma is 120 feet. A canal through this opening would therefore require a cutting of nearly 160 feet, and, besides, would have to cut through the sand ridge west of Pilot Knob in order to gain lower ground more rapidly than by keeping to the north of the sand-hills. Even in this case the length of the canal from Fort Yuma to the point where the surface of the ground is of the same altitude as the water-surface at the latter place would be at least 30 miles long.

These conclusions are arrived at from data obtained from the Texas Pacific Railroad surveys, and also from levels run by my party from Hanlon's Ferry over the divide north of Pilot Knob. In order that the canal should be entirely within the California boundary, it must cross the divide to the north of Pilot Knob. This, as has already been shown, would necessitate a long, deep cutting, partly through rock, and a passage through the sand ridge. This passage could only be effected by means of a flume or tunnel, to protect it from filling up with sand. A canal from some point below the boundary would be more practicable and less expensive in construction and maintenance. A

line of levels was run from Fort Yuma to Indian Wells, and to the dry camp beyond. The profile shows that there is a steady descent, with but few breaks, from the altitude of 137.89 feet at Fort Yuma to 38.8 feet below sea-level at a point 6½ miles west of Indian Wells. From this point the rise is rapid and constant up to the mountains which border the desert on the west. One of the branches of New River leaves the Colorado near Algodon station, and this artificial channel might be utilized in the construction of a canal for diverting the water of the river into the depressed area to the northwest. The exact course of this canal cannot be determined without further surveys, but it seems probable that it would be necessary to run it below the boundary-line nearly as far as Seven Wells in order to avoid the sand ridge. From this point it could bend more or less toward the north, according to the downward slope of the surface in that direction. The amount of cutting required is difficult to estimate without further surveys, but it would doubtless be moderate, as the water flows into this area from the river when it overflows its banks. From several persons who have resided for years in this section I have obtained the following information with regard to the flow of the water through New River and changes in the bed of the Colorado. Mr. Hanlon, owner of the ferry at Hanlon's Ferry, 7 miles below Fort Yuma, says: "The channel of the Colorado opposite Pilot Knob is now about three-fourths of a mile east of where it was at the time of Mr. Wozencroft's examination. It then runs close to the point of rocks which jut out from the eastern base of Pilot Knob. In June and July, 1861, there was a great overflow. The current at Alamo Station was more rapid and four times greater in volume than at Fort Yuma now, (March, 1876,) water flowing to the northwest toward the desert."

Mr. McMasters, station-keeper at Algodon, says:

"The great sand billows southwest from Pilot Knob are constantly moving toward the south, caused by the prevailing north winds. There has been no overflow for three years. During years of unusually high water in the river the water was 2 feet deep in the station-house, which is 600 yards from the river. (Judging by the depth of water in the well at the present time, the river must have risen about 17 feet above its present stage.) Captains Poole and Polhemus, of the Colorado Steamboat Line, say that up to 1864, during summer, at high water, boats took slough at base of Pilot Knob. The highest floods occurred in 1862 and 1867."

Mr. Conners, engineer on steamboat, says:

"Crossed New River at Indian Wells in July, 1862. Water 7 feet deep and flowing north. Volume about twice that of the Los Angeles River in July."

Mr. Redondo, butcher at Yuma, says:

"Slough from Algodon runs to New River, and from there came the water of New River during the heavy flood of 1862."

Mr. Jaeger, owner of ferry at Fort Yuma, and a resident of the place since its establishment as a military post, says:

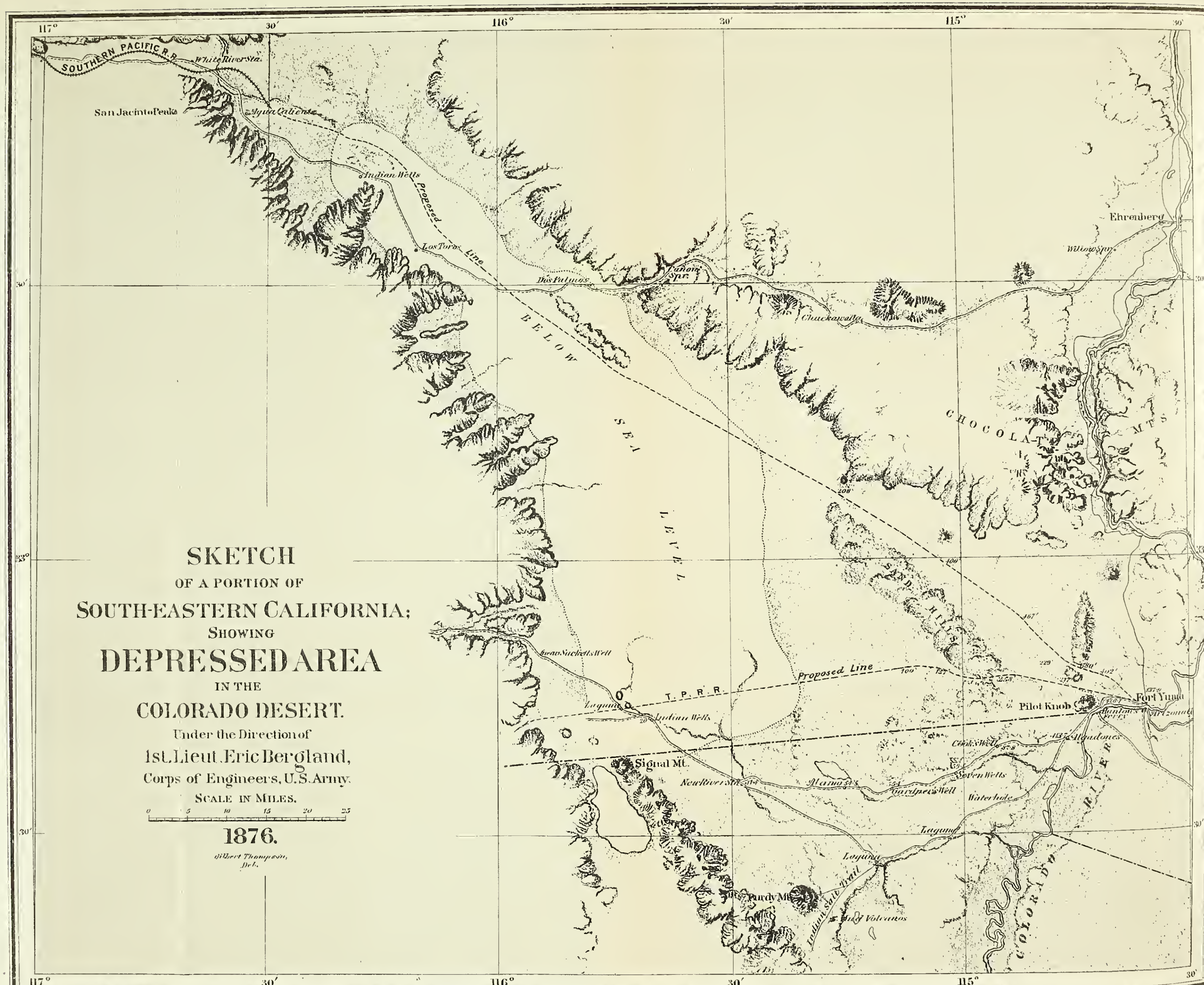
"Heavy floods in 1840, 1852, 1859, 1862, and 1867."

Tasted the water flowing in channel at New River Station in 1862, and found it fresh water. A Mr. Jones (now dead) told me that he came along the west side of the great desert basin in 1862, on his way from San Bernardino to New River, and saw in the basin a great lake some 60 miles long by 30 wide. This came from the overflow in 1862.

From information obtained and examinations made, it may be taken for granted that there is a current which sets in along the channels of New River during high floods, and that this current flows toward the north into the depressed area. At the same time, a large portion of the country between Pilot Knob and Mount Purdy is submerged, as are also portions of the plains or meadows between Signal Mountain and Indian Wells. On the subsidence of the water these plains soon become dry, and also the different channels of New River, except in the deeper portions, where reservoirs are formed, in which water remains for a year or more, depending on its depth.

Several questions of importance remain to be considered in this connection, such as probable difficulties and cost of keeping the channel free from sand blown in from the sand-hills, as well as from the settlement of the sediment in the water. These cannot be determined without closer investigation and a more detailed survey.

The area of the depressions below sea-level can be obtained approximately from data obtained from Southern Pacific and Texas Pacific Railroad surveys, together with the level-lines run by my party. The accompanying sketch shows the outlines of this area, as well as the direction and extent of the lines of profile, and altitudes at different points; these altitudes all being referred to the Southern Pacific Railroad bench-mark at Fort Yuma. From these data it appears that the northern limit of the depression is near Indian Wells, in the Coahuila Valley, and extends westwardly below the Mexican boundary. This gives an approximate area of nearly 1,600 square miles lying within the limits of California.


SKETCH
OF A PORTION OF
SOUTH-EASTERN CALIFORNIA;
SHOWING
DEPRESSED AREA
IN THE
COLORADO DESERT.
Under the Direction of
1st. Lieut. Eric Bergland,
Corps of Engineers, U.S. Army.
SCALE IN MILES.
0 5 10 15 20 25
1876.
Gilbert Thompson, Del.
117°
30′
116°
115°
SOUTHERN PACIFIC R.R.
White River Sta.
San Jacinto Peaks
Agua Caliente
Indian Wells
Proposed Line
Los Toros
Dos Palmas
Canon Spr.
Chuckawalla
Ehrenberg
Willow Spr.
BELOW SEA LEVEL
CHOCOLATE MTS
SAND HILLS
Proposed Line
T.P.R.R.
Laguna
Indian Wells
Pilot Knob
Fort Yuma
Arizona
Hanlons Ferry
Cook's Well
Algadones
Seven Wells
Gardner's Well
Waterhole
Alamo
New River Sta.
Signal Mt.
Laguna
Purdy Mt.
Mud Volcanos
Indian Salt trail
COLORADO RIVER

CURRENT OBSERVATIONS.

Observations for gauging the Colorado River were made at Stone's Ferry, Nev., Camp Mohave, Ariz., and Fort Yuma, Cal.

The surface-floats used were (for want of better materials) made from thin boards, obtained from packing and cigar boxes. A piece of sheet-lead was nailed to the under surface to steady the float and bring its upper surface near the surface of the water. A small flag was attached to the upper side by means of a wire about 3 inches long. As but one boat could be obtained at Stone's Ferry and Camp Mohave, a sufficient number of floats were made and allowed to run through without being picked up.

At Stone's Ferry the subsurface-float was a box 10 inches square by 14 inches high, open at both ends, and weighted with lead to sink it. This was attached by a cord to a small empty canteen, which served to keep it at a constant depth. To the box was attached a long trail-cord, which was paid out as the float left the boat, and by which it was pulled back after making the transits. On account of the rapid current and the resistance offered by the box, it was extremely difficult to draw it back to the boat; hence a large canteen, which was nearly filled with water, was substituted for the box. This canteen was 9 inches in diameter, and 3½ inches thick. Even this required great exertion in pulling it back to the boat, and the trail-cord finally broke, allowing the whole arrangement to float down the river.

The boat used here was large and unwieldy, extremely difficult to manage in the rapid current. As no anchor could be obtained, a substitute was used in the shape of a sack filled with stones. This had to be very heavy in order to hold the boat against the strong current, making it very tedious and laborious to handle. A base-line of 280 feet was carefully measured on the south bank and transits placed at the extremities. The times of transit were taken by a separate observer. The boat was pulled into position and the anchor dropped. It was then located by means of the transits, sounding taken, and at a signal from the observer at the upper transit a surface or subsurface float was sent out from the boat, the time and position of the float at each transit being noted by the observers. As material for surface-floats was scarce, chips were occasionally thrown in and their transits noted.

A sufficient number of soundings were taken to determine the cross-section of the river opposite the base-lines, and meander-lines were run and topographical stations made to furnish material for a complete topographical sketch of the locality.

For plotting, the section was divided into divisions of 50 feet each, numbered consecutively from the base-line.

OBSERVATIONS AT STONE'S FERRY, NEV.

The following values were obtained by measurement and computation.

The fall of the river was found by leveling to be 2.13 feet per mile, or slope $= 0.000403 = s$.

Area of section $= 5723$ square feet $= a$.

Width $= 480$ feet $= \mathrm{W}$.

Wetted perimeter of section $= 481.4 = p$.

Mean radius $= \frac{a}{\mathrm{p}} = r = 11.89$ feet $\mathrm{B} = \frac{169}{(r+1.5)^{\frac{1}{2}}} = 0.4618$.

Under the circumstances it was impracticable to take a full set of mid-depth observations; hence, reliance has to be placed on the results obtained from the surface-floats. Sections were only measured between the transit-lines, consequently the formula for the slope cannot be used. The determination of the mean from the surface-velocity has been made according to the method indicated in chapter IV, Humphreys and Abbot's Physics and Hydraulics of the Mississippi River.

No correction has been made for wind.

The mean velocity as deduced, is $v = 3.217$ feet, and the discharge, $\mathrm{Q} = va = 18410.38$ cubic feet per second.

CURRENT OBSERVATIONS AT CAMP MOHAVE.

The method of observation and the character of surface-floats were the same as at Stone's Ferry.

The subsurface-floats used here consisted of a square tin can with top and bottom covers removed. This was kept at the required depth by means of a cord attached to a small cork float which carried a small flag. A trail-cord was attached to pull the float back to the boat, after making the transits, as but one boat could be obtained near the Post. The base-line was 300 feet long, measured with a compensated steel tape. All the water passed through the section, except a small portion which flows through a shallow channel near the west bank. This had a cross-sectional area of 10 square feet, and the water flowing through it a mean velocity of 1.25 feet per second.

The fall per mile obtained by leveling was, 1.2 feet or $s = 0.000227$.

For the section at this place we have the following values:

Area of section $= a = 4628$ square feet.

Width $= \mathrm{W} = 1116$ feet.

Wetted perimeter $= p = 1116.7$ feet.
$r = 4.144$ feet.
$b = .713$ foot.

For the same reasons as at Stone's Ferry, but few subsurface-floats were observed, and the mean velocity has been computed from the mean surface velocity, as at that place, but here a correction was made, for wind. The results obtained are as follows:

Force of wind $= f = + 1.5$.

$V = 2508.64$ feet, and $Q\ va = 11610.93 + 12.5 = 11623.43$ cubic feet per second; 12.5 cubic feet added represents the discharge through the channel not included in the section.

The river fell 5.11 feet from July 9 to September 5, according to observations taken at Camp Mohave. During the interval between August 11, when current observations were taken at Stone's Ferry, and September 3, when taken at Camp Mohave, the river at the latter place fell 1.84 feet.

This will account for the greater portion of the difference between the discharge at Stone's Ferry and that at Camp Mohave, as a rise of 1.84 feet will cause a corresponding increase of section at the latter place of over 2,000 square feet. A small portion is lost by evaporation, but a considerable quantity flows below the bed of the river, in sections where the bottom is sandy, as at Camp Mohave.

CURRENT OBSERVATIONS AT FORT YUMA, CAL.

Here the conditions were more favorable. Two boats were obtained, one of which was used to pick up the subsurface-floats after passing through the sections. The sections were also more regular than at the former places, and mid-depth floats could be sent out from all boat-positions without the annoyance of having them drag on the bottom at any point. The floats were of the same character as those already described, except that no trail-line was used with the subsurface-floats. The observations were taken March 15 to March 20, 1876. The river was then at its lowest stage, and at a constant height (or nearly so) during the time of observation. The base-line was 300 feet long, measured along the right bank below the ferry. The following values were obtained:

$$\left.\begin{array}{l} A = 2726.5 \text{ square feet,} \\ W = 461.0 \text{ feet,} \\ p = 466.2 \text{ feet,} \\ r = 5.848 \text{ feet,} \\ b = 0.6234 \text{ foot,} \end{array}\right\} \text{Fall per mile as determined by leveling} = 1.21 \text{ feet.}$$

With the above values, and the formula for mid-depth velocities (formula (25) H and A), we have:

$$V = 2.809 \text{ feet, and}$$
$$2 = Va = 7658.74 \text{ cubic feet per second.}$$

The following table gives the number of floats from which the calculations were made, and the mean surface on mid-depth velocity in each division at the three places where observations were made:

Mean division velocities.

Divisions.	No. of floats.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	Remarks.
Stone's Ferry	98	.94	1.68	3.12	3.11	3.94	4.41	4.04	3.35	2.26	1.08	....	Surface-floats calm.
Camp Mohave	173	.39	.90	1.65	2.73	3.19	3.13	3.06	2.92	2.76	2.41	1.67	Surface-floats wind-up=1.5.
Fort Yuma	80	1.73	2.77	2.60	2.69	2.78	2.78	2.74	2.90	3.22	2.89	....	Mid-depth floats.

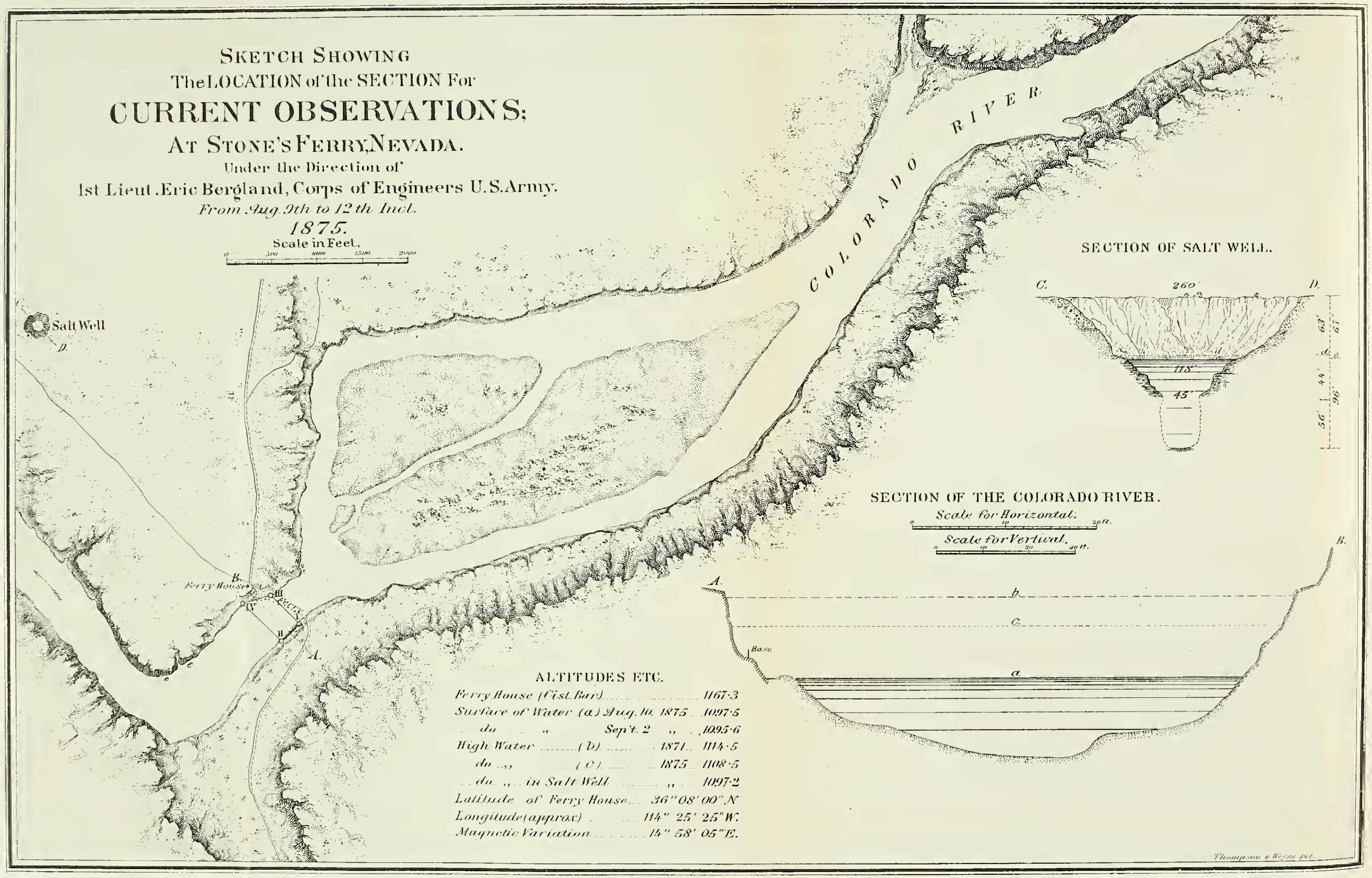
Divisions.	No. of floats.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.	XXII.	Remarks.
Stone s Ferry	98	....	....	..	....	....	....	....	....	....	....	....	Surface-floats calm.
Camp Mohave	173	1.51	1.64	1.92	2.21	2.77	3.06	2.86	2.00	1.35	.94	.50	Surface-floats wind up=1.5.
Fort Yuma	80	....	....	....	....	....	...	....	....	....	....	....	Mid-depth floats.

The accompanying sketches and profiles show the location of the bases and the topography in the immediate vicinity, as well as the form and area of the sections.

EVAPORATION.

Experiments on the amount of evaporation were made at Stone's Ferry and Camp Mohave. The vessel containing the water was placed in the river so that it would retain the temperature of the river-water. The results were as follows:

At Stone's Ferry several experiments, each one lasting from 2 to 3 days, showed the evaporation to be 0.23 inch per 24 hours. The atmosphere was dry and either calm or stirred by gentle breezes; a few sand-storms of short duration occurred during the



SKETCH SHOWING
The LOCATION of the SECTION For
CURRENT OBSERVATIONS;
AT STONE'S FERRY, NEVADA.
Under the Direction of
1st Lieut. Eric Bergland, Corps of Engineers U.S. Army.
From Aug. 9th to 12th Incl.
1875.
Scale in Feet.
0
500
1000
1500
2000
Salt Well
D.
COLORADO RIVER
B.
Ferry House
A.
SECTION OF SALT WELL.
C.
260'
D.
63'
67'
118'
45'
44'
96'
56'
SECTION OF THE COLORADO RIVER.
Scale for Horizontal.
Scale for Vertical.
A.
B.
b.
c.
Base
a.
ALTITUDES ETC.
Ferry House (Cist. Bar.) .... 1167·3
Surface of Water (a) Aug. 10. 1875 .. 1097·5
do „ Sep't. 2 „ .. 1095·6
High Water .... (b) .... 1871 .. 1114·5
do „ (c) .... 1875 .. 1108·5
do „ in Salt Well .... „ .. 1097·2
Latitude of Ferry House ... 36° 08' 00" N.
Longitude (approx) ... 114° 25' 25" W.
Magnetic Variation ...... 14° 58' 05" E.
Thompson & Weyss Del.

experiments. The thermometer ranged during these days from 75° at sunrise to 114° at 3 p. m., while the temperature of the river-water varied from 79° to 81°.5 per day. The average relative humidity was, at sunrise, 0.459, and 3 p. m. 0.173.

One experiment, made August 10, after heavy showers over a great extent of the surrounding country, showed a considerable decrease in the amount of evaporation, being 0.18 inch for the 24 hours. The temperature of the air ranged from 71° at sunrise to 99° at 3 p. m., and the relative humidity from 0.645 to 0.310. The temperature of the river-water was the same as in the previous experiments.

During the latter part of August, the experiments were continued at Camp Mohave. A strong hot wind blew during the day, commencing about 9 a. m., and lasting with but little interruption until sunset; hence the amount of evaporation was much increased, as will be seen by the following table:

Date.	Hours.	Temperature of air.	Mean relative humidity.	Evaporation in inches.	Remarks.
August 29 and 30	7 p. m. to 7 a. m	95.1–74.4	0.359	0.15	Temperature of water, 80°, calm.
August 30	7 a. m. to 7 p. m	74.4–92.0	0.399	0.69	Temperature of water, 82°; strong wind; sand-storm after noon.
August 30 and 31	7 p. m. to 7 a. m	92.0–72.1	0.351	0.11	Calm.
August 31	7 a. m. to 7 p. m	72.1–92.6	0.352	0.62	Strong wind.

From these few experiments it is impossible to form any correct estimate of th yearly amount of evaporation in the vicinity of Camp Mohave, since this amount is subject to so many variations, depending on the temperature of the air and water, relative humidity, and force of the wind. It is evident, however, that the monthly evaporation will be much greater during the four hot months, June, July, August, and September, which have an average temperature of 94°.8, than that during the cooler months. The mean temperature of May is 79°.47, while the mean temperature of the remaining months is only 65°.1 F., as shown by the meteorological observations taken at this place.

If we estimate the daily evaporation during June, July, August, and September at one-half of that observed August 29–31, or equal to 0.392 inch, and that the total amount of evaporation during the remaining months is equal to that in the four hot months, we get a total yearly evaporation of 95.77 inches, which compares well with the observed evaporations in other localities.

Thus the yearly evaporation is—

	Inches.
At Cumana	130
At Dead Sea	96
At Marseilles	73.2
At Palermo	58.4
At Manchester	41.0
At London	28.8
At Rotterdam	23
At Breslau	14.8

If we take the mean of the observed daily evaporation at Camp Mohave = .784 inch, we find that the daily evaporation from 556 square miles of lake-surface will equal the discharge of water in the river for 24 hours at the same place.

At Fort Yuma experiments were made from March 19 to April 2. The water-pan placed on the roof of the commanding-officer's quarters was exposed to the direct action of the sun, and the temperature of the water taken when the depth of water in the pan was measured. Owing to the exposed position of the vessel, and the absence of any large body of water in the immediate vicinity, the results obtained are probably in excess of what would have obtained under circumstances similar to those at Camp Mohave.

At Indian Wells Station, Cal., observations were made April 12 to 14. Here the vessel was placed in the shade of a tree.

In 1868 Dr. Lauderdale, post surgeon at Fort Yuma, made some observations, using the rain-gauge at the post.

In August, 1853, some experiments were made by Lieutenant Williamson, at Ocoya Creek, Tulare Valley, lasting four days. The water-vessel (an ordinary milk-pan) was placed on a stand 2 feet above ground, and a cover of brush built above it. All of these results are tabulated below:

FORT YUMA, CAL.

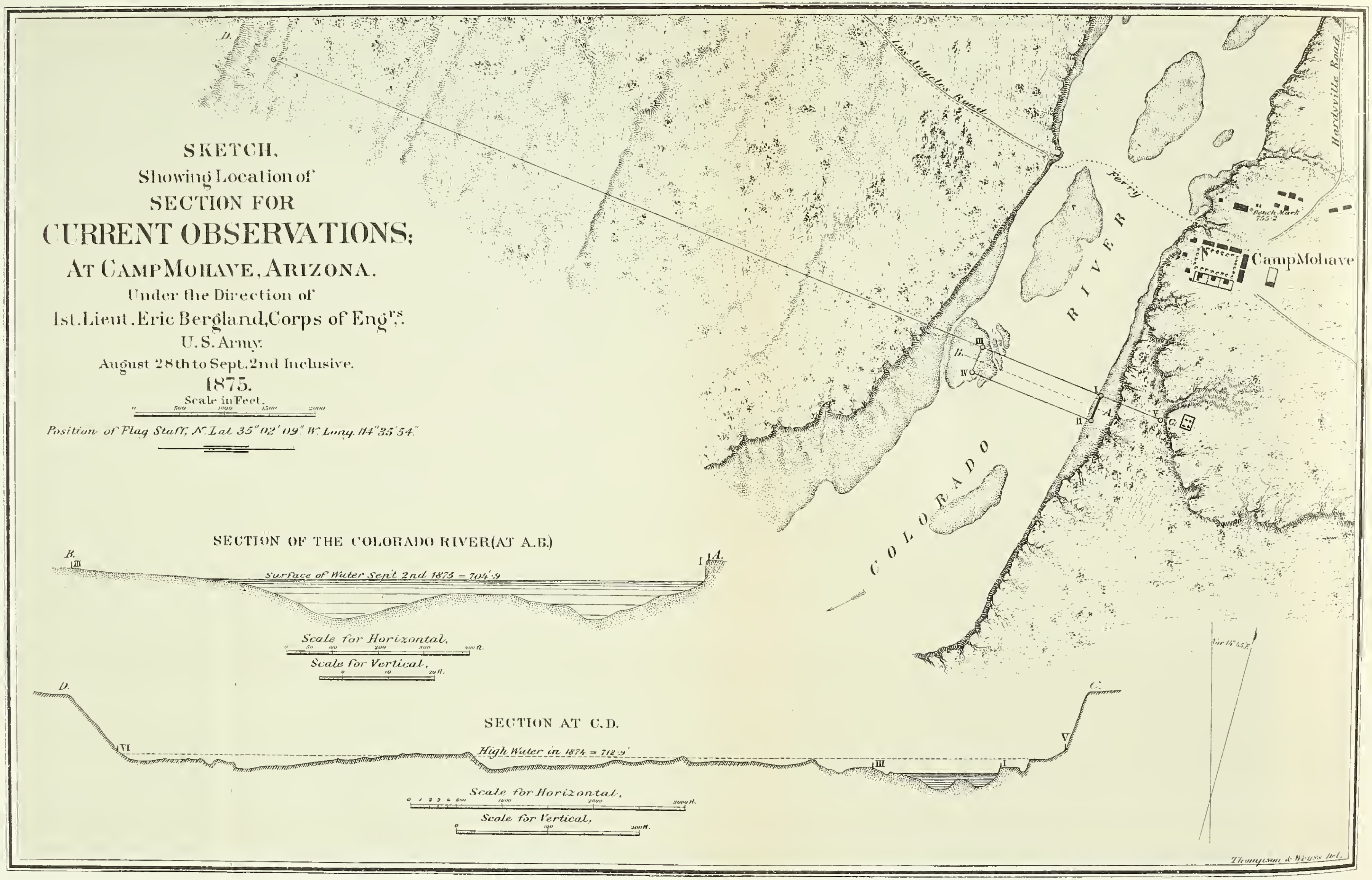
Date.	Daily evaporation, inches.	Temperature of water.			Temperature of air. Maximum.			Temperature of air. Minimum.			Mean daily relative humidity.	Remarks.
		Date.	Hour.	Degree.	Date.	Hour.	Degree.	Date.	Hour.	Degree.		
Aug., 1868	.409											Maximum daily evaporation, 0.583 inch; minimum, 0.020 inch; Dr. Lauderdale's rain-gauge.
Sept., 1868	.408											Maximum daily evaporation, 0.666 inch; minimum, 0.009 inch; Dr. Lauderdale's rain-gauge.
Mar., 1876, 19 and 20	.560	20	11.30 a. m.	91	19	2.00 p. m.	80	20	5.00 a. m.	56.4	.304	Pan showed a little leakage; wind light, clear.
20 and 21	.300	21	12.15 p. m.	68	20	4.00 p. m.	83	21	4.00 a. m.	56.7	.301	Wind very light, cloudy.
21 and 22	.330	22	12.30 p. m.	78.5	21	4.00 p. m.	77.7	22	4.00 a. m.	56.8	.389	Moderate breeze; cloudy during day; night clear.
23 and 24	.440	24	4.30 p. m.	69.5	23	4.20 p. m.	77	24	5.30 a. m.	54.0	.449	Light breeze, clear.
24 and 25	.450	25	9.00 a. m.	70.5	24	5.00 p. m.	82.8	25	5.00 a. m.	55.0	.449	Do.
25 and 26	.430	26	9.30 a. m.	71.5	25	5.00 p. m.	82.3	26	6.00 a. m.	57.0	.383	Very light breeze, clear.
28 and 29	.430	29	9.54 a. m.	69.3	28	4.00 p. m.	82.0	29	6.00 a. m.	57.0	.301	Light breeze, clear.
29 and 30	1.02				29	4.00 p. m.	86.4	30	7.00 a. m.	52.0	.224	Moderate breeze during day; sand-storm during night.
30 and 31	.57				30	3.00 p. m.	68.0	31	7.00 a. m.	58.4	.229	Sand-storm day and night.
31 and April 1	.39	31-1	6.30 p. m., and 9.20 a. m.	52-78	31	3.00 p. m.	72.0	1	7.00 a. m.	53.0	.331	Afternoon strong breeze; clear, cool night.
1 and 2	.57				1	3.00 p. m.	76.5	2	7.00 a. m.	57	.394	Afternoon strong west wind.

INDIAN WELLS STATION, CAL.

Date.	Daily evaporation, inches.	Water Date.	Water Hour.	Water Degree.	Max. Date.	Max. Hour.	Max. Degree.	Min. Date.	Min. Hour.	Min. Degree.	Mean daily relative humidity.	Remarks.
April 12 – 14	.26	13	12.00 m.	73	12	2.00 p. m.	78	13	7.00 a. m.	50.5		Light breeze, clear.
April 12 – 14		13	7.00 a. m.	41	13	2.00 p. m.	80	14	6.00 a. m.	42.8	.320	Do.

OCOYA CREEK, TULARE VALLEY, (Lieutenant Williamson.)

Date.	Daily evaporation, inches.	Water Date.	Water Hour.	Water Degree.	Max. Date.	Max. Hour.	Max. Degree.	Min. Date.	Min. Hour.	Min. Degree.	Mean daily relative humidity.	Remarks.
August, 1853, 4 days	.25					6.00 a. m.	52		3.00 p. m.	100		Pan 2 feet from ground in the shade.



SKETCH,
Showing Location of
SECTION FOR
CURRENT OBSERVATIONS;
AT CAMP MOHAVE, ARIZONA.
Under the Direction of
1st. Lieut. Eric Bergland, Corps of Engrs.
U.S. Army.
August 28th to Sept. 2nd Inclusive.
1875.
Scale in Feet.
Position of Flag Staff, N. Lat. 35° 02' 09" W. Long. 114° 35' 54".
Los Angeles Road
Ferry
Hardyville Road
Bench Mark 755.2
Camp Mohave
RIVER
COLORADO
SECTION OF THE COLORADO RIVER (AT A.B.)
Surface of Water Sept 2nd 1875 = 704.9
Scale for Horizontal.
Scale for Vertical.
SECTION AT C.D.
High Water in 1874 = 712.9'
Scale for Horizontal.
Scale for Vertical.
Thompson & Weyss Del.

The mean daily evaporation at Fort Yuma from March 19 to April 2, 1876, was 0.5 inch, and the discharge of the river per second, as found above, was equal to 7,659 cubic feet. Hence the evaporation from a lake-surface of 570 square miles would be equal to the quantity of water which the river could supply. Since the river was at its lowest stage, this gives minimum amount supplied by the Colorado and Gila combined.

A few observations were made to discover the extent of the influence of small bodies of water, as the surface of a river, upon the increase of humidity in the air. Observations made on the river-bank, with the psychrometer, show not only a decrease of temperature, but also an increase in the relative humidity. A distance of a few hundred feet from the river this influence is hardly perceptible, as a great bulk of air is mingling continuously with the stratum of cooler and moister air, which rests on the surface of the river.

Where the river-bank is lined with trees, the cooler air is longer retained and does not mix so quickly with the neighboring strata; hence in such localities the difference in temperature and humidity is considerable. Thus it was repeatedly observed at Stone's Ferry that the air under the trees on the river-bank had a temperature of 96° to 98°, when that upon the mesa, but a few yards distant, showed a temperature of 105° to 108° F.

In the following table a few observations are given, which show the extent of the influence of the river on the air:

Date.	Time.	Dry bulb.	Wet bulb.	Relative humidity.	Remarks.
		°	°		
July 24	Sunrise	90	73.2	0.399	On river-bank.
July 24	....do	92	71.5	0.339	400 yards from river.
August 31	....do	72.3	61.0	0.510	River-bank.
August 31	....do	74.4	60.2	0.428	On mesa, 400 feet from river.
August 31	2 p.m.	92.6	69.1	0.280	River-bank.
August 31	....do	95.0	66.1	0.209	On mesa, near river.

TOPOGRAPHICAL WORK.

This was carried on by my efficient topographer, Mr. Gilbert Thompson, assisted by Mr. George H. Birnie, on the first trip, and by topographer F. A. Clark and G. H. Birnie on the second. The route throughout was meandered with the Casella theodolite, and distances measured with the odometer. Bearings were taken to prominent peaks and the topography of the country adjacent was noted. Whenever time and opportunity permitted peaks were ascended, and topographical and triangulation stations established. Owing to the excessive heat experienced while in the valley of the Colorado, during the summer-months, it was impossible to make as many ascents as might have been made in a cooler climate. The mountains being destitute of water and grass, rendered it necessary to carry these supplies up the mountains, where an ascent was made, and this it was not often practicable to do.

In order to obtain the profile of the route the aneroid barometer was read at each meander-station, and at camps near the river the altitude of the ○ of the barometer above the level of the water was determined by leveling. At Stone's Ferry, Camp Mohave, and Fort Yuma a daily record was kept of the fall and rise of the water in the river, and at Camp Mohave a permanent bench-mark was placed, to which the height of the river can be referred in future. This bench-mark is a stout iron pin driven down into the ground at the east end of the hospital. Its head, which is flush with the ground, is at an altitude of 755.2 feet above sea-level, as determined by our barometer observations. An arrangement for observing the rise and fall of the river was placed a short distance from the bank.

A piece of iron water-pipe was taken and cross-wires placed at each end. The pipe was then firmly fastened to two stout posts in such a position that the line joining the intersections of the cross-wires was horizontal. A long graduated rod is placed upright at the edge of the water, when the observer looks through the pipe and takes the reading. The axis of the pipe is 42.52 feet below the bench-mark, and the surface of the water on September 2 was 50.24 feet below, or 704.96 feet above sea-level.

At Fort Yuma a bench-mark was also established by driving an iron pin into the ground near the southeast corner of the platform which surrounds the flag-staff. The altitude of the top of this pin, as obtained from Southern Pacific Railroad levels, is 204.56 feet above sea-level, referred to the Fort Point tide-gauge. The altitude of pin above surface of water in the river near engine-house, March 18, 1876, is 84.41 feet. A record of these altitudes was placed in a cavity in the upper end of the pin.

The distance of surface below high-water mark was measured wherever the point

could be accurately determined, and found to be as follows: At Stone's Ferry, 17 feet, high-water mark of 1871; south end of Cottonwood Island, 14 feet; Camp Mohave, 8 feet, high-water mark of 1872; proposed railroad crossing, north of the Needles, 20 feet; Needles, 18 feet; Camp 40, 15 feet; opposite Ehrenberg, 8 feet; Fort Yuma, 10.19 feet, high-water mark of 1862; Fort Yuma, 9.16 feet, high-water mark of 1873; Fort Yuma, 6.07 feet, high-water mark of 1875.

When the observations were taken at Camp Mohave the river had nearly reached its lowest stage, although it usually continues to fall slowly until after Christmas.

METEOROLOGY.

As previously mentioned, one enlisted man, Private Charles Lengert, Company G, Twelfth Infantry, was sent by stage to Camp Mohave to take barometric and psychrometric observations during the summer. This duty he executed faithfully and well, for which he deserves a great deal of credit.

Observations were taken in camp at regular hours, and comparisons of instruments and observers were frequently had. At Fort Yuma our barometers were compared with that of the signal-office, and a series of hourly readings were taken, which was also done at other camps where we remained two or three days. Cistern-barometer readings were also taken on mountain-peaks and on the principal divides. In this way a great number of observations were obtained from which to calculate the altitudes of the different camps.

The observations taken on the first trip were reduced and altitudes computed in the temporary office at Los Angeles during the winter months. Those taken on the last trip have not yet been computed.

The method of computation used differs from that used in the office at Washington for this reason: It was found that the horary curves at Los Angeles and Camp Mohave differ considerably; that of the latter place being much sharper and having a wider range. This was to be expected, since the climate differs so greatly from that at the former place. For this reason the proper correction was applied to the readings before computations were made.

The horary correction for Camp Mohave was used for all places included within the desert area whose climate was nearly the same, while at places west of the Cajon and San Gorgonia Passes the horary correction for Los Angeles was used. The daily means of synchronous observations were computed separately, after which the results were examined, and those which were unmistakably bad were thrown out. The mean of the remaining ones were then taken as the true altitudes. To check the results the altitudes of several camps were computed with both Los Angeles and Camp Mohave as reference-station, and in every case the coincidence was as close as could be expected.

The computed altitude of Camp Mohave, 755.8 feet, I was disposed to consider too great, as it exceeded by 100 feet all previously determined or estimated altitudes. Hence, every precaution was taken to determine this accurately. The daily means of the synchronous readings for over 70 days were separately computed. The wandering from the mean was next obtained and the observations thrown out which showed an abnormal variation, and a new mean obtained. This altitude was then used to compute the altitudes of camps already referred to Los Angeles, giving results differing but little from those previously deduced.

GEOLOGY, MINERALOGY, AND NATURAL HISTORY.

Dr. Oscar Loew, chemist and geologist, had charge of these branches during the first trip, and was indefatigable in the prosecution of his duties.

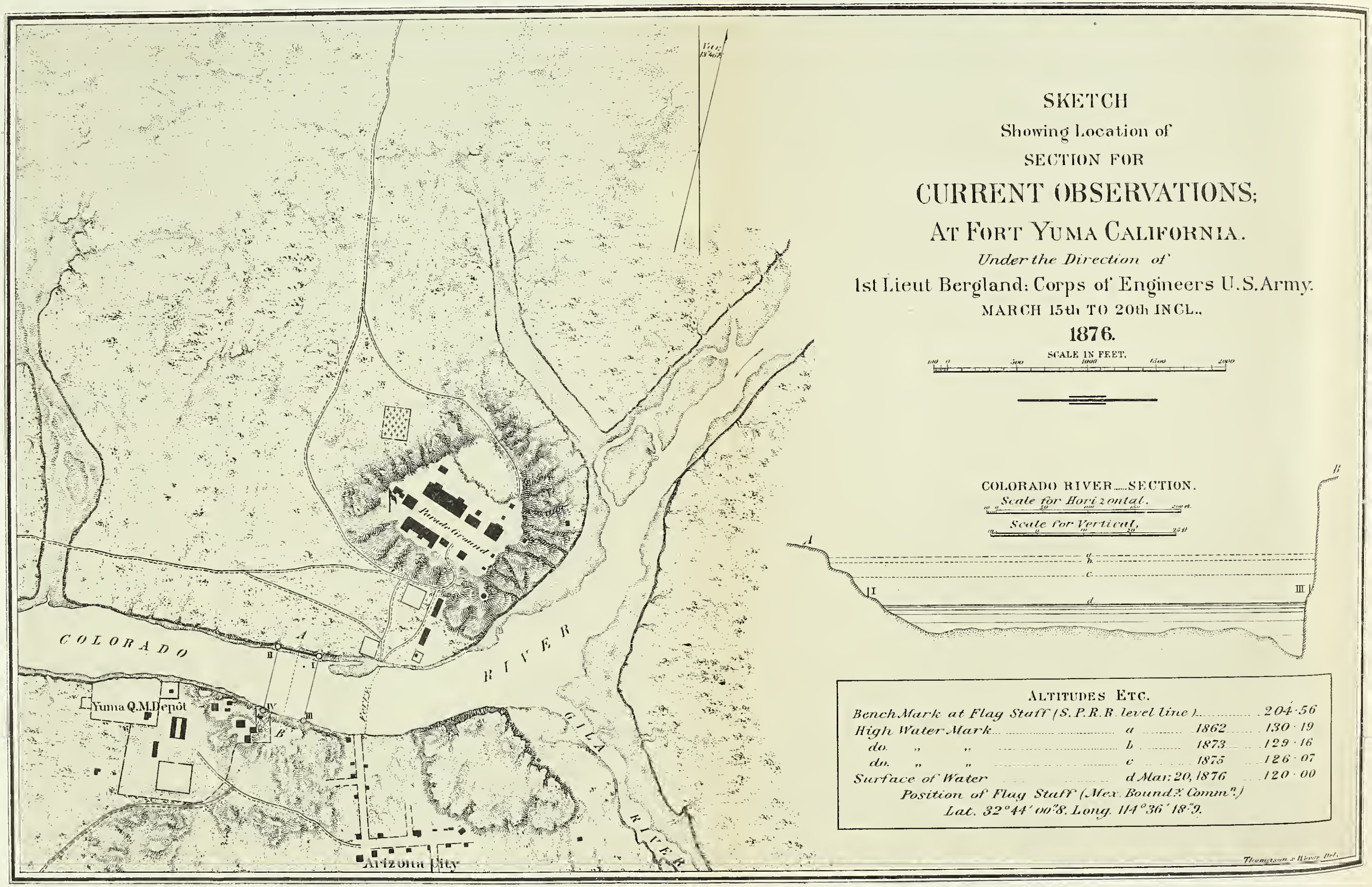
He took copious notes and sketches of the geological formations, collected numerous mineralogical specimens, visited all the mines in the vicinity of our route, and obtained many specimens of plants, insects, and reptiles.

Mineral water was taken at several points, and specimens of soils and saline deposits were obtained for analysis. He also made some original investigations on the influence of extreme heat on the rapidity of the pulse, inhalation and exhalation, and the absorption of water. He also obtained hundreds of new words from different Indian tribes, and conducted the experiments on evaporation.

It would be desirable to have his report accompany mine. On the second trip collections of the flora and fauna of the country traversed were made, specimens of soil from various localities collected, and bottles of water brought in from all thermal and mineral springs within our reach.

CLIMATE.

The climate in the Colorado Valley during the hot months is not one which a sane person would select in which to spend the summer. From the middle of June to the 1st of October panting humanity finds no relief from the heat. As soon as the sun appears above the horizon its heat is felt, and this continues to increase until a maximum is reached about 3 o'clock in the afternoon, after which the temperature falls slowly, and oftentimes very slowly, until sunrise. During the hottest part of the day


SKETCH
Showing Location of
SECTION FOR
CURRENT OBSERVATIONS;
AT FORT YUMA CALIFORNIA.
Under the Direction of
1st Lieut Bergland: Corps of Engineers U.S.Army.
MARCH 15th TO 20th INCL.,
1876.
SCALE IN FEET.
COLORADO RIVER....SECTION.
Scale for Horizontal.
Scale for Vertical.
ALTITUDES ETC.
Bench Mark at Flag Staff (S.P.R.R. level line) .... 204·56
High Water Mark .... a .... 1862 .... 130·19
do. „ „ .... b .... 1873 .... 129·16
do. „ „ .... c .... 1875 .... 126·07
Surface of Water .... d Mar: 20, 1876 .... 120·00
Position of Flag Staff (Mex. Bound.y Comm.n)
Lat. 32°44′ 00″8. Long. 114°36′ 18″9.
COLORADO
RIVER
GILA
RIVER
Parade Ground
Yuma Q.M.Depôt
Arizona City
Thompson & Rives Del.

exertion of any kind is impossible; even while lying perfectly quiet the perspiration oozes from the skin and runs from the body in numerous streams. Everything feels hot to the touch, and metallic objects cannot be handled without producing blisters on the skin. The white sand reflects the heat and blinds the traveler by its glare. Rain scarcely ever falls during the summer months, and not more than 3 or 4 inches the year round. Cloud-bursts frequently occur in the mountains, and at times we saw heavy showers all around us, but not a drop fell along the river.

The atmosphere is so dry and evaporation so rapid that the water in our canteens, if the cover was kept moist, kept at a temperature of 30° below that of the air; a most fortunate circumstance, as it obviates the necessity of using ice-water where it would be impossible to preserve ice.

Great quantities of water are drank during these hot days, and no uncomfortable fullness is experienced. One gallon per man, and sometimes two, was the daily consumption.

Notwithstanding this excessive heat, no sunstrokes occurred, although we were at one time exposed in a narrow cañon to a temperature of 120°. All of the party preserved good health during the summer.

There is no danger of catching cold in this climate, even if wet to the skin three or four times during the day or night. No dew or moisture is deposited during the night, hence no covering is required.

The hot wind which blows frequently from the south is the most disagreeable feature of the climate. No matter where you go, it is sure to find you out and give you the full benefit of a gust that feels as if it issued from a blast-furnace, and parches the skin and tongue in an instant. Then there is no recourse but to take copious draughts from the canteens to keep up the supply of moisture in the body. If water cannot be obtained, the delirium of thirst soon overpowers the unfortunate traveler, and he dies a horrible death.

To illustrate the difference in the climates of Los Angeles and Camp Mohave, the following observations are tabulated:

Hour.	Los Angeles, July.		Camp Mohave, July.	
	Thermometer.	Relative humidity.	Thermometer.	Relative humidity.
	°		°	
7 a. m	71	.695	88.8	.400
3 p. m	77	.576	104.5	.216
9 p. m	75.5	.604	94.6	.302
Mean	74.5	.625	95.96	.306

Hour.	August.		August.	
	Thermometer.	Relative humidity.	Thermometer.	Relative humidity.
	°		°	
7 a. m	75.6	....	86.5	.429
3 p. m	86.8	....	107.5	.206
9 p. m	77.2	....	94.8	.275
Mean	79.9	....	96.3	.303

In conclusion, I wish to express my thanks to Mr. Thompson, topographer, and Dr. Loew, geologist, and the other assistants, for their cheerful co-operation and attention to their duties under trying circumstances.

I am also under many obligations to the officers stationed at Camp Mohave and Fort Yuma for their uniform courtesy and assistance.

Respectfully submitted.

ERIC BERGLAND,
First Lieutenant Engineers.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in charge.

APPENDIX C.

EXECUTIVE AND DESCRIPTIVE REPORT OF LIEUT. W. L. CARPENTER, NINTH INFANTRY ON THE OPERATIONS OF PARTY NO. 3, COLORADO SECTION, FIELD-SEASON OF 1875.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF ONE HUNDREDTH MERIDIAN,
Washington, D. C., March 14, 1876.

SIR: I have the honor to submit the following executive report of party No. 3, Colorado division, under my charge during the field-season of 1875.

The party rendezvoused at Pueblo, Colo., early in June, and on the 8th day of that month the organization was completed—the party being well equipped and ready to take the field for six months' service. The *personnel* was as follows: First Lieut. W. L. Carpenter, Ninth Infantry, executive officer and naturalist; F. O. Maxson, topographer; A. R. Conkling, geological assistant; Alliston Ladd, recorder; Private J. F. Kirkpatrick, Company C, Battalion Engineers, recorder; 2 packers, 1 laborer, and 1 cook.

On the 9th of June the party left Pueblo, with orders from First Lieut. W. L. Marshall, Corps of Engineers, commanding the Colorado section, to survey the southern portion of Colorado and northern part of New Mexico, this being an area of about 7,000 square miles, comprised between longitude 104° 7′ 30″ and 106° 30′ west, and latitude 35° 30′ and 37° 20′ north.

The month of June was spent in working down the eastern side of the mountain-range which separates the water-shed of the Mississippi from the drainage of the Rio Grande; in occupying East Spanish Peak and other less prominent points as triangulation-stations, and in meandering and measuring important roads.

On the 7th of July the party crossed the Sangre de Cristo Mountains through Taos Pass and descended into the valley of the Rio Grande. Drawing supplies at Taos, the party turned northward, following the range to Fort Garland, examining en route all passes which appeared likely to afford means of communication with the eastern slope. The rainy season commenced July 4, and continued, with slight intermission, until October 1, covering the country with a luxuriant growth of grass and filling all the streams with an abundant supply of water, but proving a source of great annoyance to the party by the persistence with which clouds and fogs covered the mountains for many successive days, sadly interfering with topographical work. Taos Peak was occupied eight days without obtaining complete results; and on many other mountain-stations did the topographer spend weary hours watching a rift in the clouds, vainly hoping that it would even for a few moments disclose some distant and important station. I doubt if ever similar work was carried on under more disadvantageous circumstances than by this party during the month of July, 1875, said to have been the *rainiest* summer ever known in New Mexico.

After drawing supplies at Fort Garland, the party proceeded southward, keeping close to the foot of the mountains. By great exertion this area was completed, notwithstanding the continuance of unpropitious weather, and reached Elizabethtown August 24. Here I left the party in charge of Mr. Maxson, and, taking Conkling and one packer, proceeded to the Gallinas *mauvaises terres*, for the purpose of exploring that region and collecting vertebrate fossils from the locality visited by Prof. E. D. Cope in the season of 1874. I did not rejoin the party until October 11, at Fort Union, it meanwhile working in the range from Taos Pass to the southern extremity, below Santa Fé, and completing unfinished work in atlas-sheet 69*d*.

At Fort Union supplies were drawn for the last time at a military post, and advantage taken of the kind proffer of assistance from Capt. A. S. Kimball, assistant quartermaster, to make some much-needed repairs on pack-train before starting out for the fall work.

While at this post Mr. Conkling, in obedience to orders, made a careful examination into the geology of the vicinity, with a view to determine the feasibility of sinking an artesian well at the garrison. He reported adversely upon the project, finding that a true hydrographic basin at a practicable depth was wanting, owing to the existence of a synclinal depression in a basaltic formation of great thickness which underlies this locality. His detailed report on this subject was forwarded to you from the field.

The subject of artesian wells is one of great importance to New Mexico. The Territory possesses a large area of excellent grazing-land now almost worthless for want of water, but which only awaits the means of furnishing a small artificial supply to render it of great value. There are many localities where the basaltic formation does not occur, which appear to offer advantageous sites, with a reasonable prospect of obtaining a flowing well. A considerable sum of public money intelligently expended in this work would be a wise disbursement. If successful, it would stimulate private enterprise to sink other wells, which would operate to reclaim hundreds of square miles of an arid region now uninhabitable; while, if the experiment resulted in

failure, none could so well afford to sustain the loss as a Government whose policy has always wisely been to aid States and Territories in matters of public welfare.

The rest of October was spent on the plain country east of the Canadian River, making rapid progress with the topographical work, as the weather was now perfectly clear. Trinidad was reached November 2, and after connecting the system of triangles with the established base-line at that place, started for Wet Mountain Valley. On the 5th of November it commenced to snow, and continued stormy and very cold for ten days, making it impossible to complete the survey of the valley. Camped two days in Rosita, Colo., where the party was made very comfortable by the kindness of Mr. Livingstone, who offered the use of a vacant log house, which was very acceptable, as the thermometer stood at 6° above zero and the ground was covered with snow. During the stay in the valley the weather was so stormy that the astronomical observations necessary for the establishment of a meridian-line could not be taken, and accurate topographical work was rendered impossible. The trail leading from the Huerfano River up Williams Creek into Wet Mountain Valley was meandered; also the wagon-road from Rosita to the Huerfano by way of the Muddy Creek Pass, and such other topographical results obtained as the intensely cold and stormy weather would permit. The principal mines at Rosita were inspected by Mr. Conkling, and collections of their valuable ores secured. This little mining-town enjoys a well-merited prosperity seldom to be observed in the West. Its mines are wonderfully rich, and, being situated only 30 miles from the Cañon City Railroad, possess facilities for shipping their products, which give it superior advantages over other richer and more extensive mining-districts, but which are farther removed from railroad transportation.

Leaving Wet Mountain Valley November 17, the party started for West Las Animas, Colo., meandering the Apishpa River on the way down, from the stage-road to its mouth. Arrived at West Las Animas, the terminus of the Atchison, Topeka and Sante Fé Railroad, November 25, and disbanded next day.

The result of the season's operations is very satisfactory. The topographical work planned for the party was faithfully carried out; connection made with the bases previously measured at Trinidad, Cimarron, Fort Union, and Santa Fé; also sufficient accurate detailed geodetic data obtained to construct a reliable map of that region. During the season a total of 2,742 miles were marched; and of this number 1,199 miles accurately meandered. The number of triangulation-stations occupied was 24, the topographical stations made being 133.

Especial care was taken to determine the best routes of communication between the plains and the valley of the Rio Grande. With this end in view, the Sangre de Cristo range, which is the most formidable obstacle, was examined at all accessible places from Morino Valley northward to the Sangre de Cristo Pass. These mountains were crossed four times and a series of barometric profiles secured, which establish the fact that the Taos Pass, starting from the southwest end of Morino Valley, is the best route for either wagons or a railroad. Traveling from this place north, the next pass which can be made available for a road is called Red River Pass, and is situated at the northern end of Morino Valley. It follows up a small tributary of the Cimarron River, and crossing the range at an elevation of 9,460 feet above the sea, with an easy grade descends a little more abruptly by the Red or Colorado River, a small branch of the Rio Grande. The grade throughout the entire distance, although quite steep in some places, is perfectly practicable for wagons or railroads. But on account of the narrow walls of the Red River Cañon and the tortuous course of the stream, a considerable outlay would be required to build a wagon-road, because of the great number of bridges which would be necessary, while the cost of a railroad would be too great, for the same reason.

The next pass to the northward, known as the Costilla Pass, is impracticable, even for horsemen; while the fourth and last, called Trinchera Pass, has an exceedingly rough mountain-trail over it, which answers very well for pack-animals, but which cannot be utilized for wagons. The proximity of the Sangre de Cristo Pass, through which there is a good wagon-road, answers all purposes of travel at present, and it will probably be many years before any other means of communication for this section will be considered necessary.

Taos Pass has an elevation of about 8,625 feet, and offers many advantages over any other. There is an abundance of wood, water, and grass, until the valley of the Rio Grande is reached, when the country changes abruptly from a pastoral to an agricultural region. A proposed railroad (the Arkansas Valley and Cimarron) has been already projected along the Cimarron River into Morino Valley, and it should have the Rio Grande Valley for its objective point, as there is no intervening obstacle if constructed via Taos Pass.

Large collections in natural history were made, the movements of the party being so conducted that a collection embracing a deep vertical range could be secured during its progress from the plains, at an altitude of 5,000 feet above the level of the sea, to the summit of the loftiest peaks. And as this movement was continued in a sort of wind-

ing course down the mountains from Fort Garland to Santa Fé, it afforded opportunities for securing a valuable collection, which will undoubtedly prove extremely interesting in its bearing upon the geographical distribution of the fauna of the western mountains. In making my collections above timber-line, I received much assistance from Mr. F. O. Maxson, whose duties as topographer often required his presence at extreme altitudes.

The collection of vertebrate remains obtained from the *mauvaises terres* of New Mexico is of importance, as this locality is a new field, visited but once before, by Prof. E. D. Cope. It was a matter of regret that more time could not be spent in its exploration; but being dependent upon rain for water, movements were necessarily restricted to the vicinity of a few pools which were found; and as there were but three persons in the party, the exposed condition was a subject of anxiety during the sojourn here, on account of the number of semi-hostile Indians about. It required the constant presence of one person in camp to guard the property, while the other two went out each morning and, with rifle in hand, hastily collected the petrified bones and teeth of the huge animals which once inhabited this remarkable region. I fully appreciate the efficient aid rendered by my two companions under many trying circumstances which occurred during an absence of six weeks from the main party, without which success would have been impossible.

The geological and mineralogical collections were in charge of Mr. A. R. Conkling, who, under many difficulties, visited every mining-region passed through, and not only made valuable collections in his specialty, but also found time to render me some assistance in the department of natural history.

The past year afforded a good opportunity to see Southern Colorado and Northern New Mexico under the different conditions of a wet and dry season. The spring was said to have been the dryest ever known, and consequently the country appeared under every disadvantage. From Pueblo to the Cimarron River it was parched with the drought; there was barely enough water in some streams for live-stock, and the crops suffered for want of irrigation, although every drop was utilized economically. New Mexico, like Colorado, is a region requiring irrigation to produce crops. Although in a favorable season indifferent crops might be raised without resorting to that process, yet no dependence should be placed entirely upon natural moisture in this peculiar climate, where the rain does not fail in the season when most required by the farmer. Agriculture on a large scale must always be precarious when the means of irrigation do not exist. Most of the natives, however, are content to eke out a bare existence by cultivating a small patch of ground with wooden ploughs, and thrashing out their grain by driving herds of sheep over it. In no part of New Mexico can anything approaching to eastern thrift and industry be found. The picture which the writer saw, of a thrifty field of corn in which a herd of cattle was peacefully browsing upon the tender grain while the owners were in-doors taking their noon-day siesta, is but a type of native shiftlessness too prevalent for the common weal.

The corn raised throughout New Mexico is a short, stunted kind, well adapted to a quick growth and moderate yield. It is probably the same grain which has been cultivated on the upper Missouri River by the Indians since the days of Lewis and Clarke, where it is known as "Ree" corn, so called from the fact that the Ree Indians were the first people in that region to raise it extensively. If brought originally from Mexico or the Isthmus, its introduction to the northern tribes becomes apparent through the agency of traders and trappers who years ago were in the custom of traveling from the Missouri region to Sante Fé to dispose of their furs. But as it is a kind especially adapted to a cold climate, on account of its rapid growth, it might also have been first imported from the East, and be a variety of the original James River maize, considerably modified by climatic conditions.

The soil of Northern New Mexico, along the eastern slope from the boundary-line south to the end of the Rocky Mountain chain, is very fertile and easy to cultivate The entire valley of the Rio Grande is also a fertile tract, capable of supporting ten times its present population. This comprises about all the arable land of that region. Westward of the Rio Grande the bad-lands occur, rendering an area larger than the State of Connecticut worthless for any purpose except an indifferent grazing section during the winter-months. A short distance east of the mountains the plains appear covered with a light alkaline soil, and, being furnished with a scanty supply of wood and water, present a very uninviting appearance to the agriculturalist. The farming-land, then, of Northern New Mexico is a narrow belt on the eastern and western sides of the main range, considerably contracted toward the mountains during the prevalence of an unusually dry season; and although this region is sufficiently large to render the Territory self-supporting for all time, yet its agricultural importance will not bear comparison with other more favored Territories. Its chief wealth must always be found in the valuable grazing advantages which it affords. The writer has visited nearly all the Western States and Territories, and having had good opportunities for judging of their relative merits for agricultural and grazing purposes, has

no hesitation in declaring that as a live-stock country New Mexico is far superior to any other west of the Mississippi. Morino Valley and the mountains just north of there is a region especially adapted to the raising of cattle and horses during the summer and fall, but it is an inferior winter-range, owing to its great elevation. The adjacent foot-hills, however, afford shelter and abundant food until the storms of winter have passed. The section drained by the Canadian River and its tributaries, the Mora and Pecos, is a fine tract for all kinds of live-stock, and is *par excellence* the future great wool-growing center of the West. Far to the north, where severe winter-storms and scarcity of food cause an annual loss of from 10 to 20 per cent., and even occasionally as high as one-half, the business is considered a paying one, and if made profitable under such disadvantages, what degree of success may not be expected in a region where the winter-storms are mild and of short duration; where the nutritious native grasses furnish all the food necessary during summer and winter; and where sheep thrive without shelter, and are free from the diseases so prevalent in the East. The native animal is a descendant of the old Spanish Merino stock, considerably deteriorated by years of interbreeding; it, however, breeds back to pure Merino with wonderful facility, and may be readily improved in this way. It is quite small, and shears but about 3½ pounds of wool of a good quality; the custom of shearing twice a year is prevalent, the mild winter appearing to make this practice desirable. The Cotswold sheep in the few instances where it has been introduced has done well, and could not fail to prove a good investment on a large scale, either to raise pure, or for the purpose of improving the native stock. Sheep may be purchased by the thousand after the fall-shearing for the sum of $1 per head, and may generally be obtained at any time for $1,500 per thousand. A competent shepherd may be hired for $15 per month, and the necessary corral and buildings erected with a maximum outlay of $200. With care and attention, it appears feasible that, aided by so many local conditions peculiarly favorable to the business, the emigrant to this region who turns his attention to sheep-raising will be certain to achieve success.

The hills and mesas in the vicinity of Tierra Amarilla are covered with the finest growth of white-pine timber to be found between the Mississippi Valley and the Sierra Nevadas. Here are countless thousands of lofty trees, valueless at present, and which may remain so during our generation, but which the advent of the locomotive will one day utilize for the benefit of mankind.

The mineral wealth of New Mexico is not great, and has been generally overestimated. There is not at present a thrifty mining-district in the Territory. The gold mines at Elizabethtown still yield a moderate profit, but the gold-bearing area is of very limited extent, and must soon cease to be remunerative. Red River Cañon is a promising locality for gold, which, if present there in paying quantities, could be mined to advantage, on account of the abundant supply of water, wood, and other natural facilities which tend to cheapen mining operations and render them profitable. Gold in small quantities, with silver and copper, have already been found here, and further prospecting will probably disclose these metals in greater richness.

The mines of Trinidad, Colo., must exercise an important influence over the development of Southern Colorado and Northern New Mexico. Although the precious metals do not exist here, there are coal and iron mines of vast extent, capable of supplying the western railroads with excellent material whenever the time shall come that the price of labor will allow of competition with eastern manufacturers.

With all its natural advantages, its bright skies, pure atmosphere, and healthful climate, it may be pertinent to inquire why it is that the emigrant-wagon is so seldom seen bringing pioneers to new homes in this desirable region, while other Territories, far less inviting, are being populated so rapidly. The reason will be found to be a peculiar state of affairs, affecting the price and ownership of land, which does not exist in any other Territory. New Mexico has the misfortune to have a large part of her lands under the control of so-called land-grant companies, which have obtained grants from individuals whose title generally came from the Mexican government, before the cession of New Mexico. There are nine of these land-grants, claiming in the aggregate over 8,000 square miles of the best agricultural and grazing land in the Territory. As certain of these grants have been confirmed by Congress, their title may be regarded as secure, but others yet lack ratification. The claims of some companies conflict with others, causing uncertainty regarding the titles and sometimes annoying litigation. Where there is so much doubt concerning the validity of these land-grants, and so little desirable Government land available for pre-emption, it should not be a matter of surprise that the population of the country is not rapidly increasing. Under these circumstances, people will not settle down to till the soil, erect buildings, and fence in farms, but choose rather to engage in the less expensive business of stock-raising, which is more suitable to a nomadic life in the event of an ejectment by some more lawful claimant.

It would be economy for Government to buy up all these claims at a good round sum and throw the land open to settlement under the homestead laws. The speedy increase in the population and amount of taxable property, and general prosperity of

the people, would soon more than repay the original outlay, and change this conservative, inert Territory into a thriving rival of her less-favored neighbors.

Very respectfully, your obedient servant,

W. L. CARPENTER,
First Lieutenant Ninth Infantry.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in charge.

APPENDIX D.

EXECUTIVE REPORT OF LIEUTENANT R. BIRNIE, JR., THIRTEENTH UNITED STATES INFANTRY, ON THE OPERATIONS OF PARTY No. 2, CALIFORNIA SECTION, FIELD-SEASON OF 1875.

UNITED STATES ENGINEER-OFFICE,
GEOGRAPHICAL SURVEYS WEST OF ONE HUNDREDTH MERIDIAN,
Washington, D. C., May 1, 1876.

SIR: I have the honor to submit herewith report of operations of party No. 2, California section, for the field-season of 1875.

The country to be surveyed by the party comprised the eastern portion of atlas-sheet 65, of which Owen's Lake, California, forms nearly the central figure. The main topographical features of this eastern portion, lying approximately between longitude 116° 30′ and 118° 15′ west from Greenwich and north latitude 35° 35′ and 37° 20′, proved exceedingly simple. Here was found most markedly a type of that large section of country lying east of the Sierras, in Nevada and California, where the general trend of the mountain-ranges is very nearly parallel to the Sierras, and, so far as our area extended, uniformly decreasing in altitude to the eastward, and becoming more barren and sterile as they decrease in height, seeming to endeavor to assimilate themselves to the alkaline sandy and desert valleys that separate them. It is also to be observed that these valleys decrease in altitude with the ranges, that is to say, considering the main divisions of ranges and valleys. First the Owens River Valley separates the Sierras from the Inyo range; and second, considering the Argus as but the southern extension of the Inyo range, we find this separated from the Panamint range by the Salinas and Panamint Valleys, these valleys being separated by an east and west spur that tends to connect the Panamint and Inyo ranges; third, Death Valley separates the Panamint range from the Amargosa on the east. The order of the altitude of the ranges has been found as stated, and of the valleys, Owens River is the most elevated, Salinas and Panamint are next, and Death Valley the lowest, being below the level of the sea. Eastward of the Amargosa range is the valley of the Amargosa River or the Amargosa Desert, which rising a thousand feet or more above the level of Death Valley, broke the uniformity heretofore observed and, moreover, formed the limit of our survey to the eastward.

On the 23d of June, 1875, the party left your rendezvous camp near Los Angeles, Cal., composed as follows: Louis Nell, chief topographer; F. Brockdorff and W. S. Waters, recorders; Benjamin P. French and Lenardo Aguilar, packers; Frank Reyer, cook; E. S. Stevens, private Company G, Twelfth Infantry, and myself as ex-officer and field-astronomer. After two days' march the cook was discharged, and Andrew Hoos employed in his stead.

At Los Angeles we were distant about 120 miles from Pilot Knob, a mountain-peak situated nearly on the southern line of our area. Up to this point, however, there was to be traversed the main road from Los Angeles to Panamint, Cal., much traveled before the establishment of the Southern Pacific Railroad terminus at Caliente, when a road from that point to Panamint and the surrounding country offered better facilities for the receiving of freight from San Francisco.

The route of the party was along the road first mentioned, following nearly the line of the Southern Pacific Railroad as far as Spadra, Cal., about 30 miles from Los Angeles, and then passing through Cucamanga.

We were detained at Martin's, Cajon Pass, until July 2, awaiting the return of Mr. Nell, who, with a small party, left us at Lytle Creek, June 29, to make the ascent of and the necessary observations upon San Antonio Peak. From Martin's, through the Cajon Pass, the road crossing the divide a few miles east of the crossing of the proposed Los Angeles and Independence Railroad into the Mohave Desert, we crossed the Mohave River at Huntington's, and again near the cottonwoods, after it has made its remarkable turn to the eastward. Its bed here is dry most of the year, and the prevailing west and southwest winds, blowing uniformly from noon to midnight in the summer season, pile up ridges of the sand athwart its course, and one wonders that its waters could flow here at all, rather than that the volume of water seen 20 miles higher

up the stream should here be nowhere visible. A few settlers are found along the river, groves of cottonwood, and a little grazing, but the soil is too sandy to be productive, and the difficulty of obtaining water for irrigation, except in early spring, is almost insurmountable. Water for drinking purposes is obtained from wells. From the Mohave we cross a low divide into a valley, in which is Black's ranch; the soil of the valley incapable of cultivation, but sand-grass and a coarse grass somewhat used for hay in the country are found, and afford sustenance for several hundred head of cattle. Good water is obtained from wells.

July 7 we reached Granite Springs, near the southwestern base of Pilot Knob, and this peak was ascended for triangulation and topographical purposes. In our last day's march to this camp, marching northward, we came obliquely upon a line of volcanic rock, that could be clearly traced in a slightly northeast direction, having completely shattered the group of hills forming the Cosco Mountains, and, in the southern extension of Owens River Valley, showing a probable elevation of the land, now a low divide, to the south of what now forms Owens Lake and the cutting off of the river, for there are indications of an old river-bed south of this divide; an immense old crater and lava-flow is found again just south of Cerro Gordo Peak, and in the same general direction, in the northern part of Owens River Valley, is a great group of old craters, extending into the foot-hills of the Sierras. The earthquake of 1872 took place along this line, and slight shocks, not felt at any great distance to the east or west of it, are of frequent occurrence.

From Granite Springs the party moved westerly, by way of Surveyors' Well and Willow-Tree Spring, to Panamint Station, (a station of the Cerro Gordo Freighting Company, about 75 miles from Panamint,) over an old and little-used wagon-road, passing also by the El Paso (silver) mines, that have not been worked for several years. From Panamint Station a small party ascended Owen's Peak, in the Sierra Nevada range, near by, and then made its way northward through the mountains, principally along the south branch of the Kern River, to Olancha Peak, and after ascending it, met the remainder of the party at Olancha post-office, (near the eastern base of the peak and the southern end of Owens Lake as well,) whence they had come by the direct wagon-road along the base of the Sierras from Panamint Station.

In the great longitudinal basin in the Sierras, through which flows the Kern River and its south fork, the two streams only being separated by a subsidiary ridge, and especially about the headwaters of the streams, fine meadows abound and excellent pasturage-ground extending up the mountain-slopes. These are utilized in the pasturage of cattle and sheep, principally the latter, thousands of head being brought in the warm season from the settled country of the valleys nearer the sea-coast, the pasture-grounds there being insufficient to sustain them. Many of these lovely meadows are entirely laid bare and their sod almost ground into the dust, and nearly to the tops of the highest peaks these flocks of sheep find their way.

The party remained in camp at Olancha two days, and then proceeded, skirting the foot-hills of the Coso Mountains on the north by way of Arab Spring to Darwin, a new mining-town, only established in the early part of 1875. A topographical station was made near at hand, and the town and some of the principal mines located in position. [For a report of the mineral resources, &c., of this mining-district, see report of Dr. Loew, who visited this place in October, 1875.] The town was found in a growing and most flourishing condition. Water had been conducted by pipes from springs distant about 7 miles, and in sufficient quantity for the use of the town and furnaces. The party camped on the night of the 23d of July in Darwin Cañon, about 7 miles from the town, where a magnificent spring bursts from the side of the cañon. Its waters, however, sink after flowing a few miles and before reaching the valley; and such is found to be the case with all the other little streams of this range (the Argus) and those of the Panamint and Amargosa ranges to the east of it.

Returning through Darwin, we moved a short distance westerly to Coso, an old but now abandoned gold-quartz mining-town (except by a few Mexicans) in the Coso Mountains. From these hills at present is obtained the supply of wood and charcoal for Darwin; this supply, with any great demand, as seems probable, will, however, soon be exhausted. From Coso, following a wagon-road, we crossed the Argus range into Shepperd's Cañon, and thence directly across Panamint Valley to Cañon Station, (of the Cerro Gordo Freighting Company,) in Panamint or Surprise Cañon, on the eastern slope of the range, a few miles from the valley. We remained in this camp about a month, (until August 28,) occupied in measuring a check base-line in Panamint Valley; the ascent of Telescope Peak; a trip to Lookout and Rose Spring mining-districts; another to Panamint; and another to Borax Lake and factory, in which the Slate range was crossed; Argus Peak occupied for topography, a route meandered from this peak northward to develop the topography of the angle formed by the junction of the Argus and Slate ranges, (Borax Lake lying between these ranges,) and to occupy Maturango Peak of the Argus range.

Panamint Valley, a little more than 1,000 feet above the sea-level, is exceedingly desert and alkaline, and, together with the other low and desert valleys in this country, very

hot in summer. Hot springs are found at nearly the lowest point, which is on the east side of the valley, at the base of the Panamint range. A valuable salt marsh is near them.

The mining-town is situated near the summit of the range, in a cañon of the same name, (Panamint,) and is reached from Panamint Valley by a very steep but excellent wagon-road. (Dr. Loew also visited this place for report.)

While at this camp, all our animals, except a few required for short trips, were sent a distance of about 30 miles, where pasture could be obtained; we were thus enabled to recruit materially those that had developed signs of weakness.

From this place, with a portion of the party, I crossed the head of the cañon in which the town is situated, and from the summit of the pass we overlooked Death Valley and the Amargosa range beyond on the east and Panamint Valley on the west.

The first portion of the descent to Death Valley by trail was very steep. In the cañon through which we passed grass and a short running stream were found, also a small cultivated piece of ground, where vegetables were raised with facility by irrigation. Entering Death Valley, we turned northward and camped two days at Bennett's Wells, nearly on the edge of the great alkaline deposit of the valley; but permanent and very good water, only a little alkaline, was found in the wells—three or four holes scarcely more than 6 feet deep—while a coarse green bunched grass furnished pasture for the animals and mesquite trees grew sparsely around. Our barometric observations show this camp to have been within a few feet of the sea-level, (below.) Two trips were made to determine the lowest point of the valley. On the first day, moving out into the valley nearly in an easterly direction, I was induced to turn northward from the washes met with, showing a flow of water had been in that direction. I believe, however, the slight difference of level throughout allowed the water (in the wet season) to be driven by the prevailing winds from the south, and at least greatly assisted in the formation of these channels.

This valley on the south receives the flow of the Amargosa, and on the north that of Furnace Creek and of the more northern and higher portions of the valley, with much of the drainage of the Panamint and Amargosa ranges. Water collects in these drains only in the wet season. The southern and nearly flat portion of the valley seems to extend north and south for 20 to 30 miles. From what I could observe, I am inclined to think there are two low portions situated on either side of the center of this flat portion. Two trips across the valley, made after this first, the one to the south and the other to the north, showed a less elevation.

It is to be remarked, however, that our first and central trip was not entirely across the valley, as in the other cases, but was far enough to support the opinion expressed. The second day we crossed the valley to the south of the first line, and, as before remarked, our observations showed a greater depression, which was near the eastern edge. In this vicinity, where water had evidently stood not long before, the surface was an unbroken crust of salt, probably an inch thick; the appearance of a beach and water-waves was thoroughly impressed upon the white surface of the salt as the water dried up, and the effect was very fine.

Even at this time, nearly the driest season of the year, great difficulty was experienced in traveling about the valley; the marshy, soft ground in one place, and the dry honey-combed loose surface in another, made traveling with animals exceedingly dangerous, while again the ground was smooth and baked hard enough to readily support them. On both these days we were compelled to leave our animals and make the rest of our journey on foot, sometimes sinking nearly to the knees in ash-colored mud beneath the salt. This flat portion of the valley is about 5 miles wide, (opposite Bennett's Wells,) and while the lowest point may not have been discovered, enough has been developed to show that there is a large tract nearly flat, and a great portion of this approaching 100 feet depression from the sea-level. I may here remark that probably the only way to thoroughly solve this problem would be to run several instrumental level-lines through the length of the valley, and this would be almost impracticable from the marshy character of the ground; many places are, I am sure, impassable.

Two fresh-water springs are found on the western edge of the flat north of the wells, but the waters of both seem somewhat medicinal, and are said to be unwholesome. We did not suffer as much from the heat as had been anticipated, although the thermometer was noted at one time at 145° F. in the sun; yet, as at this camp we could receive all the benefit of the breeze from the south, which blew a great portion of the time, the oppressiveness of the heat was obviated, except when there came, as at intervals, blasts of hot air.

It is claimed by intelligent persons who have visited the valley that water remains in a body in portions of the flat throughout the year. I was unable to discover any such body of water. (1 September, 1875.)

From Bennett's Wells we moved northwardly along the western border, and crossed to the northeast, over the old emigrant road to Furnace Creek, (noting a second portion at Salt Springs lower than on the central trip,) where we awaited the arrival of the rest of the party that had separated from us at Cañon Station, and had moved along the west-

ern foot-hills of the Panamint range to Willow-Tree Station, (on the Los Angeles and Panamint road via Pilot Knob;) there occupied Brown's Peak, in the southern portion of the range, for triangulation and topography, and passed to the south of the range by Leach's point and Owl Springs into Death Valley at Saratoga Springs; thence along the dry bed of the Amargosa by Resting Spring and Clark's Fork, and left the Amargosa to pass to the east into Water Valley and Pah Spring, this last the rendezvous of a numerous band of Indians; thence by Ash Meadows to our camp at Furnace Creek, which they reached September 8, having been absent thirteen days.

Furnace Creek is formed by numerous warm springs that have their rise (all about of the same altitude) in the low slopes on the north side of the cañon, the warmest of which is a little over 90° F. The stream, 3 or 4 miles in length, sinks where it reaches Death Valley. The south walls of the cañon are a curious strongly-cemented conglomerate, and a small amount of calcareous matter seems to be the only deposit from the springs.

After occupying a peak to the south, in the Amargosa range, for topography, we moved to the northeast, crossing this range by a pass heretofore unexplored, and then north across the Armagosa Desert to Oasis Valley. This march of 38 miles was entirely destitute of water or grass, and, having first to cross the range, but 20 miles were accomplished at sundown, a night march was made until 1 a. m.; and, starting early the next morning, a good camping-place was found at 10 a. m.

Bare Peak, near by, was occupied, and a trip made to occupy Toe-li-cha Peak, in the northeastern corner of atlas-sheet 65. While this was being done, a reconnaissance was made with a light party, to gain the necessary information for recovering the Amargosa range into Death Valley. Several springs were discovered along the eastern slope of the range, but Boundary Cañon was found the first practicable pass south of Grape-Vine Cañon. Between these passes is the highest portion of the range, and some very pretty mountain country on the eastern slopes, which are gentle, and there is good grazing. Piñon is almost the only wood found. The place is a resort for Indians, who gather the piñon-nuts in quantities in the fall. Here was also first observed the peculiar *blinds* made by the Indians just beside the springs for killing the birds—quail and some very small varieties—that come in numbers to the only water to be had. These blinds have the general appearance of a bee-hive, are made of rushes and small boughs interlaced, with an opening for entrance on the side away from the spring. The interior is large enough to seat one person, a small opening being toward the water through which to shoot the arrow, and with string attached for recoving it no alarm is produced. In Oasis Valley duck-blinds were found constructed in the same way near little artificial ponds.

The ascent of this range on the east side is easy, but, crossing to descend into Death Valley, the faces of the strata are broken into abrupt descents, and *boxed* cañons are almost universal and often impassable.

From Oasis Valley we passed the Armagosa range by Boundary Cañon, stopping to occupy Wah-guy-he Peak, and, entering Death Valley a second time, camped at Salt Wells. This portion of the valley is, if possible, more dreary than the southern part, for, except this salt marsh, where grows a tall green grass, but of poor quality for grazing, its general appearance is a great stretch of white sand, interspersed, it is true, with mesquite trees, but these are perched upon hillocks sometimes 15 or 20 feet high, their roots having protected the sand about, while the wind has carried away the intermediate portions. We found the water at the Salt Wells unfit for use, (during a portion of the year it can be used,) but in crossing the valley and at a short distance from our camp we found several holes with a small supply of very good water. The excavations showed a stratum of saturated sand but a little below the surface, and the indications are that it would not be difficult to obtain water by a little digging almost at any place in this vicinity. The valley is here about twelve miles wide. Our march was through Cottonwood Cañon, in the Panamint range. We reached water and a camping-place at sundown. On this day's march our animals were much exhausted, two having to be left, unable to travel; one died almost immediately, the other was brought into camp the next day. The water met with had been sufficient only for ourselves, and riding animals and some of the pack-mules had been without for forty-eight hours; and in this one encounters the difficulty of traveling with more than a few animals. Besides the scantiness of the grazing, the springs are too small to furnish sufficient water.

We passed along the stream of several miles in length, lined with cottonwoods, and following a good trail, camped at springs near the summit of the range and the head of the cañon.

The uniformity of the ranges is broken at this place, and a spur that separates Panamint from Salinas Valley juts out from the Panamint range. The highest portion of this spur, somewhat plateau in character, is interspersed with springs, and good grazing is found. A mule-ranch has been established. Occupying a triangulation-station here, we passed along the spur and crossed the Cerro Gordo range by a very steep trail, and came to the mining-town of Cerro Gordo on the eastern slope and near the summit, (for

report of mines, &c., see Dr. Loew's report,) and thence by excellent wagon-road down the mountain to Cerro Gordo landing, on Owens Lake. The country from Panamint to Cerro Gordo was without settlers, except the small garden in the cañon east of Panamint.

Skirting the northeastern shore of Owens Lake, we crossed the river by a bridge a few miles above the lake, and thence through Lone Pine to Camp Independence, arriving the 3d October, and remained until November, small parties being sent out from time to time to prosecute the work in the vicinity.

October 6, Mr. Nell occupied a triangulation-station on the eastern divide of the Sierras and nearly west of Camp Independence.

Careful observations were made to connect this post with primary triangulation points, and a series of sextant-observations taken for latitude.

October 9 we started to occupy Mount Whitney, the highest peak in this portion of the Sierras, and probably the highest in the range. The most feasible route was found by returning to Lone Pine and ascending the very steep eastern slope of the Sierras by the way of the Hockett trail, (from Lone Pine to Visalia, Cal.,) passing the divide by the headwaters of Cottonwood Creek, and then turning northward from the trail when in the basin of Kern River, which drains directly the western slope of the peak which we occupied October 13. The view from this peak is most grand and comprehensive, more than 11,000 feet above the Owens River Valley, overlooking it and the ranges to the east, and including almost in one view the two great ridges on either side of the basin of the Kern River and the rocky barrier at its head that separates it from King's River to the north and west.

In the Sierras we find the strata dipping to the west, just the opposite of what is found in the Amargosa range, (the eastern one of the uniform system heretofore remarked.) A close study of these ranges in connection with the intermediate ones, the Inyo, Argus, and Panamint, would I think, in this particular alone be very interesting. In the Inyo (next to the Sierras) the strata seem but little inclined from the perpendicular. This range has been considered remarkable from its height compared to its base, rising 7,000 to 8,000 feet from a base of scarcely more than 8 miles, both sides being at this point (Inyo Peak) about equally precipitous.

The glacier action to be seen on the western slope of Whitney's Peak is very grand; the immense size of the cañons and the smooth and polished surface of the rocks extending up their sides attest the action that once has taken place; the eastern slopes of the range observed near Camp Independence also bear evidence of this action, notably on Glacier Cañon, just north of Kearsarge Pass, and almost at any place along this slope may be found broken rocks worn and polished on one side, showing they were fixed in position when this abrasion took place.

Returning from Whitney's Peak, we were compelled to leave our pack animals at Lone Pine to recruit, while Mr. Nell and myself made a trip to occupy Cerro Gordo Peak and New York Butte, both of the Inyo range; then collecting the party, we returned to Camp Independence. Next a trip was made to occupy Wau-co-ba Peak, (Inyo range,) returning by the Eclipse mill and mine and crossing the river at the mill. A triangulation-station was also made upon one of the group of craters just south of Big Pine.

The Owens River is scarcly fordable within 20 miles of its mouth, but is crossed by three bridges. The banks, though low, are steep, and the river-bed soft or the approaches swampy. The sediment brought down by the river is deposited in bars in the lake, perpendicular to the thread of the current; behind them are forming lagoons. The bed of the river near its mouth is a hard-pan formation, in which deep and shallow places alternate, seemingly without reason.

In the valley is distinctly observable a fissure formed by the earthquake in 1872, when the ground sank in the valley and along the west bank of the river; and next to the foot-hills is observed the exposure of the west side of the fissure. There seemed a striking resemblance between this and a terrace formation, its position facing the valley also, and I think in a short time, when the bank shall have become rounded by the weather, it will be hard to distinguish from an old terrace.

On November 3, having completed as far as practicable the area assigned us, the party moved toward Caliente, Cal. Passing along the western shore of Owens Lake, the road keeps along the eastern base of the Sierras to Tehacapai Pass, and through this to Caliente, where we arrived November 12.

At Little Lake a halt was made to occupy a station in the Coso Mountain, and for me to visit interesting boiling springs that had been reported in the vicinity. Dr. Loew has analyzed the waters from these springs and reports upon them.

Supplies for the party were received at Los Angeles for forty days, at Panamint for sixty days, and at Camp Independence for forty-five days.

Lieutenant Whipple and party arrived at Caliente also on the 12th, and Mr. Klett and party on the 15th. The parties were disbanded as soon as practicable, and the property inventoried and packed in cases. Lieutenant Whipple, in charge of train and property, left for Los Angeles on the 19th. Mr. Klett and myself left the last, on the night of the 19th, for Washington, D. C.

The party was in the field one hundred and forty-three days. A system of triangles was closed over an area of about 8,000 square miles of territory, and the topography of this area, with about a third as much more obtained by running meanders exterior to the system, was, as far as practicable, carefully studied and can be mapped.

The parallel ranges of mountains, with but 15 or 20 miles between their crests, and these marked with well-defined points, afforded an excellent opportunity for carrying on the triangulation.

A base, 6.78 miles in length, was measured in Panamint Valley, where we were able to find a nearly level and favorable surface, and well-conditioned triangles enabled us to include two prominent mountain stations (Telescope and Malurango Peaks) in the first extension. This system was definitely connected with that of the Los Angeles base by the two parties occupying in common Whitney's, Olancha, and Owens Peaks.

In the measurement of the base an instrumental line was laid out between the extremities and marked by small white flags planted at intervals of fifty paces, obstructions and irregularities of surface were removed, and the line carefully measured with a spring-steel tape-line, compensated for temperature. The line runs a little west of north from the south end, which is near the center of the valley, and about one-fourth of a mile north of the direct road from Shepperds Cañon to Panamint Cañon.

This end is marked by a rough-hewn stone monument, projecting 15 inches above the surface, rectangular in shape, 6 by 8 inches, and 1875 inscribed on the side away from the base. In this valley our survey was also connected with the land-survey, a three-point station being made at section-corner of ranges 42 and 43, township 20, sections 7, 18, 12, and 13. This section-corner is situated 5 miles, and bears north 70° west, from the northern extremity of the base, which is a monument of rough stones.

A series of observations was made to determine the azimuth of the base, and of sextant observations for latitude at the south end. In addition to this, sextant observations were taken at sixteen other points, which were also connected by instrumental bearings with the triangulation. In all, thirty-six sextant latitude stations were made, and complete observations for azimuth of sides of triangles at four different points.

Magnetic variation was determined by observations on Polaris; thirty-nine results have been recorded, including those determined at the apices of triangles, where the difference between the magnetic and true azimuth of one of the sides was, whenever practicable, carefully determined, the true azimuth resulting from computations afterwards made.

Eighteen triangulation-stations and thirty-two topographical stations, including the eighteen triangulation-stations, were made.

At starting, the party was well supplied with instruments for taking the meteorological observations required; both our barometers were out of order by July 12, but new tubes being received at Panamint in August enabled us to use this instrument for the remainder of the season, good comparisons for error being made on our return.

The party was unfortunate in that, from breakage or loss, the full set of meteorological instruments was not carried throughout the season; and the results of the observations taken have been curtailed on account of this; the meteorological observations were taken throughout to conform to your written instructions, and, together with the odometer record, duplicated and compared in the field. Eighty-two cistern-barometer stations were made, and four hundred and sixty-two aneroid stations in addition.

The principal roads and trails were meandered, and a table of distances for these, with remarks as to wood, water, &c, prepared in the field.

Twelve hundred and sixty-one miles were meandered and 611 traversed but not meandered; thirty-three point-stations were made as checks, and six hundred and seventy-two other stations upon meander-lines.

The instruments used werethe sextant, Stackpole & Brother's, for latitude; Wurdemann theodolite, graduated to read to 10″ of arc, for triangulation; Wurdemann graduated and Young & Son's small transit, for topography and meander work; cistern and aneroid barometer, with wet and dry bulb, and maximum and minimum and pocket thermometers, for meteorological observations; the compensated steel tape for accurate and the odometer for road measurements. Short meanders were sometimes made with the pocket-compass.

A number of mining-camps were visited, and everywhere the party met with the kindest treatment from the people of the country and a willingness to impart information that proved of great value to us in traveling. Especially are we indebted to Capt. A. B. MacGowan and the officers at Camp Independence, and Mr. Maclean, the superintendent of the Cerro Gordo Freighting Company, for assistance rendered us.

The members of the party, with scarcely an exception at any time, worked with a unison and cheerfulness that is a pleasure for me to record.

Very respectfully, your obedient servant,

R. BIRNIE, JR.,
First Lieutenant Thirteenth Infantry.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in charge.

Appendix E.

EXECUTIVE AND DESCRIPTIVE REPORT OF LIEUTENANT C. C. MORRISON, SIXTH CAVALRY, ON THE OPERATIONS OF PARTY NO. 2, COLORADO SECTION, FIELD-SEASON OF 1875.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., May 1, 1876.

SIR: I have the honor to render executive and descriptive report as follows of the operations of party No. 2, Colorado section, of the survey for field-season of 1875.

Reporting in person to Lieut. W. L. Marshall, Corps of Engineers, in charge of the Colorado section, at the camp of organization, at Pueblo, Colo., on June 5, I found the *personnel* of the party completed as follows: First Lieut. Charles C. Morrison, Sixth Cavalry, executive officer and field-astronomer; topographical assistant, Mr. Fred. A. Clark; recorders, Messrs. W. C. Niblack and Anton Karl; general assistant, Mr. W. H. Rideing; packers, Alex. Harbeson and Samuel Abbey; laborer, N. Bascom; cook, Green Terrell.

The necessary supplies, record-books, &c., being received later, the party took the field June 12. Moving southward upon the Santa Fé stage-road, our objective point being Fort Garland, we crossed the Sangre de Cristo Pass June 15, and reached the post the following day. It is a military post for four companies, built of adobe or sun-dried brick, not very prepossessing in appearance, although very prettily located on the eastern edge of San Luis Valley, near the junction of Sangre de Cristo and Ute Creeks. From the latter of these the post draws its supply of water by *acequias*, or ditches.

My instructions were to carry the survey from Fort Garland westward, to cross the San Juan range north of the San Antonio Creek, to extend the triangulation on a portion of this range unfinished the previous year. Having completed this, to go to Fort Wingate by way of Pueblo Pintado, surveying a large section in that vicinity; to examine Washington Pass as to its possible use as a wagon-pass; thence to proceed down the Bonito Creek to the Puerco of the West; thence to Wingate, surveying the Zuni Mountains southeast of Wingate, and large areas on each side of the Wingate and Albuquerque wagon-road; to carry the survey from the Rio Puerco of the East to longitude 104° 7′ 30″, between latitudes 34° 50′ and 35° 40′. Having finished this belt, to proceed to West Las Animas, Colo., the disbanding camp, reaching there by November 15, the return route being up Ute Creek to its head. The route followed was essentially as directed, and incurred traveling by this party of 4,627 miles. The area surveyed during the season was 11,300 square miles.

It became necessary to divide the party for a portion of the time to accomplish the survey of this great area. During such time Mr. Karl acted as assistant topographer to the main party, and did so very satisfactorily indeed. The ration-points used during the season were: Pueblo, Tierra Amarilla, Fort Wingate, Albuquerque, Santa Fé, Anton Chico, and Stone Ranch, rations being distributed to those points from Santa Fé and Fort Wingate.

The triangulation was carried over nearly the whole area and profile lines run.

Hypsometrical data were gathered by careful observations taken regularly throughout the season. Latitude-observations were made, when possible, at all camps not located by triangulation.

The examination of the country between Tierra Amarilla, N. Mex., and Fort Defiance, Ariz., developed two possible wagon-routes of communication to the latter place by way of Washington Pass; thence into Southern Utah or Northern Arizona.

The one, striking west just south of Nacimiento, crosses the main divide not far from the eastern head of Chaco Creek, follows down this drain past Pueblo Pintado to where it passes out of the cañon opposite Mesa Techada; thence, a little north of west, crossing the Vaca Creek, nearly opposite the pass; thence over Washington Pass; thence, bearing to the south, skirting the Black Lakes, down the drain of the Bonito past Fort Defiance, nearly to the mouth of the creek; then crossing over to the main wagon-road from Fort Wingate to Prescott, Ariz.

The second route crosses the Atlantic and Pacific divide at the head of Cañon Largo, where the main wagon-trail crosses north of San José; thence running down Cañon Largo about 17 miles, it leaves the main trail, crosses over to the southwest to Ojo Nuestra Señora; thence running nearly due south it strikes the Chaco in the vicinity of Pueblo Pintado; thence it follows the same route as above.

On either route there would be a scarcity of water.

Little work would be necessary on the first route from Nacimiento as far as Pueblo Pintado; from there there would be some blasting, cutting, and filling in Cañon Chaco, as also in Washington Pass, particularly near the summit on the eastern slope; here the pass narrows, and a short, sharp rise around a point of rocks would require much blasting. A very careful selection of route would be necessary on the whole eastern approach; the rise is almost 3,000 feet. On the west little difficulty would be met

with; a little blasting would be needed about 200 feet below the summit, and some cutting and filling, with two or three small bridges, would be all required.

On the second route little additional difficulty would be experienced, except south of Ojo Nuestra Señora. A line of bluffs running nearly east and west would necessitate a very careful selection of route in this vicinity. One of these, in connection with a proposed wagon-road from Fort Garland, crossing the Rio Grande at Colonas or Myers Ferry, thence to San Antonio, from there by the southern or Brazos branch of the Chama to Tierra Amarilla, would make a very direct route to Northern Arizona.

The distances on these routes will be found in tables of distances to be published from this office. It is not intended to convey the idea that these routes are now practicable, for they are far from being such; but that they are possible routes, necessitating work. There is at present a good road as far as San Antonio, Colo.; from there but a horse-trail; in many places not even that.

No traverse-line was run from Pueblo to Garland, as that portion of the country had already been surveyed in previous years by your parties.

From the summit of Sangre de Cristo Pass the San Juan range was seen enveloped in smoke of burning forests; and upon leaving Fort Garland there was still no more than a few snow-capped points visible. It certainly was not encouraging for triangulation, as we were dependent upon Banded Peak in the center of this section for the developing of the work to the south and west, the connection with Mount Taylor being very necessary, and only to be well obtained with a clear horizon.

Two miles out from Garland, June 19, we crossed Trinchera Creek, a clear mountain-stream, as yet but little utilized for irrigating purposes, but capable of supplying water for quite a tract of land now almost barren. Further on, the Culebra was reached, with its Mexican ranches scattered along its banks. Flowing through low ground, with several channels, it makes much marshy land in its broad valley which could be easily reclaimed and cultivated.

As we approach the Rio Grande the bare basalt crops in places, and a few hundred yards below Myers or Colonas Ferry the cañon of the Rio Grande heads, here but a few feet deep, gradually increasing till it reaches 800 or 1,000 feet in depth—a narrow black gorge in the eruptive rocks—the great outlet of what has once been a large lake, gradually drained by its outlet cutting deeper, till finally the sandy plain of disintegrated lavas was left, rich in soil but unproductive for the want of rains or economic distribution of its present waters. The ferry is a small flat-boat swung from a cable stretched from bank to bank, the boat being propelled by the action of the current. At this point, or possibly a little farther north, would be the best railroad-crossing for a route to follow the Rio Grande, forced as it would be, in order to be built at a reasonable cost, to follow the plateau on the west bank, to come down the river again by the Ojo Caliente Creek and Rio Chama.

The route of the party from Myers Ferry was up a short valley, thence passing over a low divide down into the drainage of the San Antonio Creek. Here the country had been overflowed by the San Antonio and Conejos Creeks, which unite a few miles below where we made our camp, having between them a large marshy flat which could easily be drained, and quadruple the land now under cultivation could be devoted to agriculture had the people the necessary enterprise. At the southern end of this valley the San Antonio Mountain, a great wooded dome of eruptive rock, rises high above the surrounding country. Isolated as it is it would be a fine natural triangulation-point were it not for its wooded crest. A built station on the tree-tops would make it a fine central point to carry the triangulation from the eastern or main rocky range to the west.

The Conejos, up which lay our route for the morrow, is a broad mountain-stream, at this season difficult of crossing, swollen as it was by the melting snows of the mountain. Several promising Mexican plazas attest the appreciation of the agricultural advantages of the section, and the many sheep in the valleys near the mouth of the cañon speak well for the grazing. The Prospect Peaks, standing as sentinels over the entrance to the country beyond, rise up from the plain just north of the mouth of the cañon. The forests were still smoking, giving promise of much waiting. We left the main road 4 miles above the town of Guadalupe, and commenced our work in the mountains. Without the serrated outlines of granite-formations the range is none the less beautiful in its many inclosed valleys and cañons. Originally a great plateau of eruptive rock over the Cretaceous sandstones, it falls gradually, with trend to the southeast, extending from the main San Juan range in the northwest till it disappears in the foot-hills and low mesas in the vicinity of Ojo Caliente. Broken up by many cañons and small valleys which have been carved out in long ages, there is left in this section but a system of narrow tables, here and there a half-mile across, generally but a few hundred feet, frequently but a ragged edge along which a man cannot pass. It is not a mountain-system, but a succession of steppes, narrow flats, and small basins with vertical rims. With summit above timber-line, bare of vegetation, in the day-time warm and pleasant, at night freezing, the year round, with slopes covered with snow, stands Banded Peak in the center of this region, the southern prominent point

of the range. Dimly outlined on the southern horizon, 158 miles away, is Mount Taylor. Nearly as far away to the southwest and west are the Tunicha range, the Carrizo Peaks, and the Sierra Lata; to the northwest and north, white with snow, the innumerable peaks of the San Juan range, like the spires of the churches of a wide-spreading city, are seen. Springing from its sides flow the Los Pinos Creek with its heads on its northeast slope, the Navajoe from its northwest slope, and the two northern heads of the Chama from its southern sides. Divided here by the narrow, nearly vertical wall, but thirty feet across its top, waters of the Atlantic and Pacific take rise, the one to find outlet by the Rio Grande in the Gulf of Mexico, the other to seek the Pacific by the Colorado River and Gulf of California.

The nearest prominent points to the north are Meigs and Monument Peaks. The country between is broken into small flats and basins, in which cluster many little lakes from the melting snows. The more protected of these are bordered by a dense growth of quaking aspen, which, with its silvery bark and bright green leaves, contrasting with the somber foliage of the pine, is far more beautiful to the eye than enjoyable to him who has to pick his way through these groves, dense as cane-brakes. At times crowded into the lake by the impenetrable growth, the pack-mule mires. There is no escape. Standing knee-deep in water of melted snow, you must take off his pack and pull him out by ropes. The delay has so belated you that in the approaching darkness you can no longer trail the mules that have gone on before, and are compelled to make camp without shelter and nothing to eat. At this season of the year it was impossible to travel over the country, on account of snow and water. The drifts to be crossed had not a crust strong enough to bear the mules, and they were in constant danger of being wedged in between hidden masses of rock. Around the entire horizon the forests were still burning as they had been for over a week; there seemed no prospect of its abating, and we were constrained, by our rations running short, to postpone the occupation of Meigs and Monument Peaks till later in the season.

In September the topographer returned, and accomplished this. Although loath to do so, (for it would have required but four more days had the horizon been good to finish the work here,) we turned our backs on Banded Peak and followed down the middle branch of the Chama. Taking its head immediately under this peak in two lakes, which find their outlet in falls some 600 feet high, the Chama gathers these waters into a bright stream 10 feet wide and 2 deep. With quite a volume of water where they flow over the rim, these falls are but spray before they reach the basin or amphitheater, inclosed on all sides by nearly vertical walls, excepting the narrow cañon through which the stream finds outlet.

This whole region abounds in game. The elk, black and white tailed deer, grizzly, black, and cinnamon bears are numerous. The banks of the stream are lined with aspen, spruce, and fir, while higher up the bare rocks give silent testimony of the colder air where even the grass is refused a living.

Following the stream down we emerged from the mountains and entered the flats of the Upper Chama, in the section known as Tierra Amarilla of Northern New Mexico. On the east the spur continues to the southeast; on the west we see the mesa-country bordering the great barren Bad Lands of the Territory. Near the point the trail leaves the mountains the middle fork makes junction with the western fork of the Chama, and together they flow to the south, bearing slightly east. We soon passed through the towns of Los Ojos and Los Brazos, and camped a little above the town of Nutritas, the agency for the Jicarilla Apaches. It being issue-day the Indians had come in for their supplies and were encamped about the town. Nearly all of them were Utes and Apaches, although some few Navajoes were easily picked out from among them by their straight, slight figures and intelligent faces; they had come over to trade with the other tribes and were willingly taking advantage of issue-day to obtain supplies.

Our camp is in a forest of pine trees which grow in this flat as upon the mountains. Such is the elevation of Tierra Amarilla that in winter the snows are very heavy, but in summer the grazing is fine and the country cannot be excelled in that season as a cattle-range. A very undemonstrative Fourth of July was here passed, posting records and recuperating our animals for the hard stretch of plain country to be surveyed.

With no guide but our instruments and the information that we shall probably find but one spring of water permanent in its flow, we start for Fort Defiance. About 4 miles from Las Nutritas the Chama is crossed at the Mexican town of La Puente, so named from the fact that formerly there was a bridge across the Chama near this point. Moving nearly due south we strike the Chama again and camp for the night. Cretaceous sandstones crop along our route during the day. The grazing is good, but after we passed La Puente no cultivated land was seen, although numerous small flats along the Chama might have been reclaimed, and much land on the right bank might be devoted to agriculture did the people partially drain the Chama and throw its never-failing water on the sage-brush plain extending towards the Gallinas. Our camp was near the crossing of the old Santa Fé and California trail, now entirely unused.

From here we pass to the west of the Gallinas Mountains, a low range much broken by short cañons, but having no marked distinctive features other than the point at its

northern end, and the deep rugged cañon through which the Gallinas Creek breaks its way, cutting the range asunder to its very base. Frequently dry, the stream, from the recent rain-falls, now runs its banks full. Just west of the stream are the Bad Lands, or dry, barren Cretaceous deposits, wherein are found the fine fossil-beds. A succession of hog-backs, or uplifts with cliff-faces to the east and gradual slopes conformable to the dip of the rock on the west, extend to the divide between the Atlantic and Pacific drainage. They form, with the Gallinas Mountains, a valley by no means attractive to the eye, scant in vegetation, even the sage-brush and greasewood becoming scarce, the scattered piñon-trees alone breaking the forbidding hue of hot sandy drifts.

Pushing west from the Gallinas we cross the divide, here but 7,561 feet elevation, and descend upon the Pacific slope by even grade, easily to be made favorable to wagons, and follow the heavy Navajo trail which runs down Cañon Largo from Ojo San José. The rain falling in torrents brings but the consolation that, if we have to make a camp where there is no permanent water, we can probably find enough in pools to partially satisfy the animals.

The day's march was 26 miles through a hard rain, and we camped with only such water as we had carried in our water-kegs and that soaked up by our clothes, tents, and packs.

The following day we passed Ojo de Nuestra Señora, a fine bubbling spring, situated in a drain running into Cañon Largo. The ground round about is marshy; large bowlders are scattered over the ground low mesas of sandstone inclose the drain, and numerous trails concentrate at this one volcanic spring in the desert. From here we traveled southward, over a gently rolling country, here and there broken by low mesas, with little to distinguish them one from the other, the drainage-lines all converging toward Cañon Largo. After some 18 miles' travel a sudden descent or cliff is reached. A deer-trail gives us means of descending some 400 feet into Cañon Blanco drainage, which drain unites farther north with Cañon Largo near its outlet, San Juan River. The grazing is very poor, and the country would be almost worthless, but for the lignite which crops at the head of these cañons.

Our route lay to the south, our objective point being the Pueblo Pintado, an ancient ruin, before referred to in your reports as Pueblo Bonito. It is situated on the south side of the Chaco Creek; creek simply because it flows water in the rainy season, but perfectly dry nine months of the year. Its southern and western walls are still standing, showing in its present state at least four stories; the outlines of one hundred and three rooms are easily traced on the ground-floor. The walls on the east, south, and west sides have been at right angles to each other; that on the northern front facing the water has been an arc of an arch, with three large towers built so as to defile all the ground between the building and the stream. In the interior has been a court with several circular rooms, like the present *estufas* or assembly-rooms of the Pueblo Indians of New Mexico.

The whole structure is of stone and wood; no evidence of iron is found. The masonry consists of thin plates of sandstone, dressed on the edges, laid in a coarse mortar, now nearly as hard as the stone itself. Every chink is filled. The usual stone is from half inch to an inch thick, with occasional layers of stone 2 or 3 inches thick occurring regularly every 15 to 18 inches' interval, evidently to strengthen the masonry. The exterior face of the walls is as smooth as one built of brick and beautifully plumbed. At the base, 2½ feet through, the wall at each story decreases in thickness by the width of a slight beam, on which rest the girders of the floor, the larger ones setting in the wall. There are no doors opening on the side away from the court, and the only means of light seem to have been through the inner rooms and through some small port-holes opening outward on the stories above the first. There are no perfect arches found in the building; the only approach to such being in having the successive layers over the windows extend one beyond the other till one stone can span the space. Usually the doors and windows were capped by lintels of wood, which were but slight round poles, with their ends, as were those of all the girders, hammered off, apparently by some stone implement. In one of the circular rooms was found what appeared to be an altar, built out from the side of the wall in the very center of the building; it was probably here that their worship, since lost or perpetuated in an altered form by the present Pueblos, was carried on.

The most striking peculiarities of the buildings were the wonderfully perfect angles of the walls, the care with which each stone had been placed, the perfection of the circular rooms as to their cross-section, and the great preservation of the wood. With an architecture so advanced in other respects, their glaring inability to tie joints in corners, each wall being built up against and not united with the others, makes it comparatively weak; indeed, it is to be wondered at that the walls are still standing, depending as they do each upon its own base, without abutments.

Usually the Chaco is dry; doubtless at one time there was plenty of water, for an apparent difference in the weeds and grass just above the building indicates that the ground was once cultivated. We found no implements other than a section of a

metate, or hollow trough of stone, similar to those now used by the Indians and Mexicans, in which they grind corn and coffee. Innumerable fragments of pottery were found very similar, although none perfect, to that made by the present Pueblo Indians.

A few hundred yards down the stream, as also above the buildings, are found traces of other buildings, with, in some cases, the outlines of the walls easily distinguishable. In the cañon, which commences less than three miles below, are seven or eight other ruins equally well-preserved on the cliffs above; these are what have been apparently watch-towers.

South of the Chaco the country rises to a table-land, presenting on its southern and western slope for about 30 miles but two places to descend the cliffs, which are about 300 feet nearly vertical. On the southern face, probably 120 feet above the valley, with no visible way of getting up, nor could we reach them from above, we found several smaller buildings, probably coeval with the larger ruins, presumably used by the shepherds. They are built under the overhanging walls of the cliff-rocks.

On the level surfaces above were found numerous cisterns from 2½ to 8 feet deep, hollowed out in the rock by the action of water, possibly aided by the hand of man.

Descending from the table-land, which we were a day in doing, as a ramp had to be built for each mule down certain vertical places, we camped on a small drain, tributary to the Chaco from the south. A mile north of us was the Mesa Fachada, an isolated mass, which looks like a grand old church and marks the outlet of the cañon Chaco. On another drain just west of this we found another ruin similar in the main features to the others, but differing in that it had a tower-like room running clear to the top, inclosed in rectangular walls, so that the perimeter of cross-section was a square on the outside and circle internally, the segments where the wall was thickest being filled up by rubble-masonry. The ruin was on a slight elevation above the valley. From opposite the face of the former ran a built wall of earth, with stone revetment across the drain, possibly a roadway with bridge, more probably a dam, 10 feet across the top, 5 feet high, and 15 feet across the base. Here, as at the other ruins, was found much broken pottery. In one of the ruins on the main Chaco drain the topographer entered a room now almost under ground from *débris* of the falling walls. It was entirely destitute of furniture or tools of any sort, but was very interesting in that it showed the manner of making the floors; also that the interior walls were plastered with a mortar containing but little lime. In the walls were small square recesses, as if for shelves. The ceiling, which was the floor of the room above, consisted, first, of heavy poles about 5 inches in diameter and at intervals of about 3 or 4 feet; on these transversely were placed smaller poles, and again across these in juxtaposition were laid small square poles, all held down by withes. Nothing bore evidence of the people leaving suddenly, for, though the hole was barely big enough to admit of a man crawling through and had only lately been unearthed by the rains, there was no sign or trace of anything manufactured by man left behind; nothing but the bare walls. In this we were much disappointed, for it was but reasonable to suppose, if we could find a room in fair state of preservation, that some articles of household-furniture might remain.

Throughout this whole section the grazing was very indifferent, and we should have suffered much for water were it not for the rains, and even that which we obtained while camped on the Chaco, where the water was most abundant, held in suspension fully half its volume of silicates.

Nothing could have been more welcome than the refreshing draught of cold water obtained when the small branch of the Vaca Creek, which flows from the eastern side of Washington Pass, was reached. Here were camped several bands of Navajoes, who pushed into camp and endeavored to be extremely friendly, rather too much so, for it proved to be but a cloak for the opportunity of the better making small peculations. They were, however, generally well disposed to whites, but seemed fearful that the object of surveying in their country was either to establish new lines to their reservation or to run a railroad through it. The latter possibility seemed particularly distasteful to them; they were shrewd enough to have seen the civilizing effect of railroads elsewhere. There is possibly no Indian of the plains as intelligent as these Navajoes; of straight, lithe figures, wonderfully square shoulders, the average man tall, quick of movement, with bright, intelligent, rather pointed faces, they are easily distinguished when mingling with other Indians. While still having all the characteristics of the nomadic tribes, they are better able to support themselves. Even now they raise corn and beans and have very large herds of sheep and horses; they have many four-horned sheep. The head of an old buck presents a very strange appearance; in addition to the heavy horns turning up, there is still a second pair equally as large, which turns down and back; and one old fellow had what appeared to be a third set of short horns growing from between them, directly to the front. As I saw this latter, however, at a distance, I could not vouch for their being, as the Indian told me, a third set. They claimed to have quite a number of six-horned bucks; the four-horned were certainly numerous.

At our third camp in the Tunicha Mountains, near the western mouth of the Wash-

ington Pass, we saw the squaws making blankets. It is a slow process. Between two upright poles are three horizontal ones, two of them placed apart a little more than the length of the blanket, running vertically from one to the other; the warp-threads are stretched; then those of the woof are put in, one at a time, by hand; a narrow thin board is put in after each of these, and they are hammered down by striking the board with a cleet, which they handle so skillfully as to rarely break a thread. Some of the yarn is furnished by the Government, but the best white yarn they make from the wool of their sheep, and the finest red they make by picking an English cloth and spinning the yarn. These blankets are a perfect protection against rain, and are wonderfully warm.

The Tunicha section is a beautiful country and abounds in game. The grazing is particularly good, and there is much arable land in the reservation. The tribe is said to number 9,000. It is fortunate they are peaceably inclined. They rarely do more than steal a few sheep or horses. Although there was, at the time we were there, some little reason to fear an outbreak, some turbulent spirits grown up since the last Navajo war were anxious to show their prowess, and we heard dark rumors of how they were going to kill all the whites in the country. The better counsel of the older men, who had large herds to risk and little to gain, prevailed against such attempt.

On the evening of the 20th of July we reached Fort Defiance, the agency for these Indians, now unoccupied by troops. It is situated in a little valley at the mouth of Cañon Bonito. The masses of sandstone rock tower up above it several hundred feet. The narrow gorge in the red sandstone through which flows one branch of the Bonito is very impressive, but not so striking as the cañons farther north. The Tunicha range, which breaks down into low mesas a little to the south of this, is or has been a large plateau, which is now broken up into many beautiful valleys. There is much fine timber and plenty of water. From Defiance the party traveled by two routes, the main party following the road to Wingate, the topographer going down the Bonito some distance and crossing over to the Rio Puerco of the West, which is a dirty little arroyo or wash emptying into the Little Colorado. The first night out from Defiance the main party camped at Rock Spring, a small pool formed by a dripping spring under the rocks a little to the east of the road and about half way between Defiance and Wingate.

At Wingate we spent several days recuperating the animals and posting records. We are much indebted to the kindness of the officers there, who offered us every private and official assistance possible. Wingate is a very pretty four-company post, built of adobe, situated some 15 miles west of the divide between the Atlantic and Pacific waters. It is dependent on a large spring, the Ojo del Oso, for its supply of water, which is carried by ditches and pipes through the whole post. It stands on the northern slope of the Zuni Mountains, which rise about 1,000 feet behind it. The adobe, or sun-dried brick here used, has as main constituent a pale-blue clay, which is very pleasing to the eye as well as possessing the more practical advantage of being particularly durable for that class of masonry. The roofs are shingle; not the ordinary earth ones used throughout New Mexico.

After our rest at Wingate we started into the Zuni Mountains with renewed energy, and found them far different from what we had expected. Through what has always been represented as the crest of the mountains, we found an anticlinal axis. Following the axial line was a wide valley, running nearly the entire length of the range, abounding in the most beautiful glades, with bunch-grass 18 inches high standing as thick as it could grow, here and there rooted out in the damper places by red and white clover. These natural meadows were a rare treat to our animals, which had so long been living on but scanty provender. Ten or twelve sheep-ranches already located and one large cattle-ranch showed that these advantages were not unappreciated. Here we replenished our larder by mutton as well as by venison killed by one of the party. The game is very abundant. Bear, elk, deer, and turkeys were seen in numbers, and had we had time there would have been rare sport. From Gallinas Spring, in the eastern part of the range, 4½ miles from Agua Fria, the party broke up into three parties, the topographer, with two packers, going to the famous Inscription Rock, with instructions to proceed eastward from there; the main party going to Agua Fria, thence to old Fort Wingate; I myself going down the Cañon de Zuni to Blue Water, up through the Blue Water Cañon, and back to old Fort Wingate. From old Fort Wingate, which is on the waters of the Ojo Galle and about 3 miles south of it, with the assistant topographer we ran two more lines through the Zuni Mountains, occupied several topographical stations, and from there went to McCarty's ranch, which is on the San José Creek just under Mount Taylor, Gallo Spring furnishing most of the water for the San José, its other heads being Agua Azul, which is the outlet of the Valles Ovagones of the Zuni Mountains. Here we waited the arrival of the topographer. The Zuni Mountains, which we had finally covered by the survey, are but a low range, reaching in no place much over 9,000 feet. Heavily timbered, with but few prominent points, its northern slope is very gradual, but it is much cut up by small cañons. Parallel to its axis runs a valley having on the north a line of hills or hog-backs nearly perpendicular on their

southern face. To the south, the gradual rise of the main slope, presenting a mass of timber to the eye, runs up to the west. Here it drops down nearly vertically, 500 to 600 feet into a broad valley, extending through the range, varying in breadth from ½ mile to 4 miles. Beyond the valley again rises the crest, vertically, or nearly so. From there it slopes off again into the plains through which runs the Zuni Creek, on whose banks is found the old town of Zuni, one of the ancient "seven cities" discovered by the old Spanish explorers in the sixteenth century. The whole range is very finely grassed and, at the time we were there, well watered, although some of the springs are said not to be permanent in very dry seasons. To the southeast from the range are a number of extinct craters, and it is but sorry work to the surveyor to go through them. Although beautiful natural triangulation-points, they were only beautiful as such, for in traveling over them the animals had almost no grass and were without water three days. The shoes were torn from their feet by the sharp points of lava. Leather ones were substituted. Everything was done to try to save their hoofs, but without success. Two of the five died. The other three were nearly worthless for some time. One poor brute had his hoofs worn away till the bone protruded below the hoof. Another had his leg broken by breaking through the shell over a large lava-bubble and becoming wedged in the crack. The men were too much exhausted, nor had they torches, to explore a cave discovered in the lava, which seemed in its black depths to be of immense size, running in the direction of the great flow which extends for miles around. Hungry and utterly worn-out, they reached the main camp August 16, leading their animals.

From here, after one day's rest, the party was again divided; the topographer with one man was sent north to occupy Mount Taylor, thence to cross over to the Puerco at Casa Salazar, from there into the Jemez Mountains, thence into Santa Fé. Refitting there, he was to return to Banded Peak to do the little work left undone earlier in the season. The main party proceeded to Sheep Spring. From here work was done to the southwest, in the Sierra Verde and Mesa Lucera, by the assistant topographer and myself. We suffered some from want of water; at two camps in succession we had but a pint each, and that strongly alkaline.

After a hot day's work, nothing is more necessary than water; food can much more readily be dispensed with. In a perfectly-dry climate, where evaporation from the body is so great, it needs but a short abstinence from water to produce suffering.

Returning from the Mesa Lucera, we found the main party encamped at Juelites, a forsaken little Mexican town in a broad, brownish-red flat, where everything looks burned up; the adobe-houses, the parched soil, the gaunt goats, the lean dogs, the very men, look as if they were being slowly consumed by hunger and heat. Few towns in New Mexico will compare with Juelites. Our first camp after leaving this place was at Isleta, on the Rio Grande, which we were glad enough to see. It is an Indian town, some 15 miles south of Albuquerque, on the west bank of the river. The fruits, grapes, and melons were just ripening, and were a great treat to us. The grapes of the Rio Grande Valley are particularly good, being in flavor very similar to the California grape. The country traversed from McCarty's ranch was mainly a succession of sandstone mesas. The valley of the San José, through which runs the principal road, has on its north mesas of red sandstone, capped with white, rising in successive steps about 800 feet above the valley. South of the valley the Mesa Lucera, some 600 feet above the valley, stretches to the southwest, till it unites with the foot-hills of Cerro Verde to the southeast, till it reaches the foot-hills of the Ladrones Mountains. It is gently rolling on top, gradually rising to the south in a line of small hills. The surface-rock is basalt.

Near the town of El Rito, which is some 12 or 14 miles west of Sheep Spring, is a deposit of gypsum. The water is strongly impregnated with the salts of lime and soda, making it almost undrinkable. The grass has been fair, but was well eaten off throughout the whole valley of the San José. The herds of the Mexican town of Cubero, the Indian town of Laguna, and the Mexican and Indian towns of El Rito, fill the valley to its full grazing capacity. This stream finds its outlet in the Puerco, just to the north of Quelites. The latter stream, flowing between high banks of sand and clay, mainly the former, is quickly drunk up by the porous thirsty earth, and, though a fine stream at its head, it barely runs water enough at this point to indifferently support two or three ranches, and a large part of the year is perfectly dry. Between Quelites and Isleta, on the narrow neck of land, are several craters, which form very pretty cones. Being entirely bare of timber, they were a valuable acquisition in the secondary triangulation.

The valley of the Rio Grande, up which our route lay, is a broad open valley, in which not more than a fourth of the land has been utilized for agricultural purposes that could be taken advantage of. Passing through the towns Pajarito, Padillas, and Atrisco, we reached Albuquerque, the county seat, and second only to Santa Fé in size in the Territory. Formerly a military post, there remains but the falling walls to show where once was the garrison. In a low bottom but little above the river-bed, the location does not strike one favorably, and yet it is quite a thriving place. From Albuquerque to Santo Domingo, indeed to Peña Blanca, the fields were looking well and

the fruits were everywhere to be found. The grapes of Bernalillo were very fine. Here the valley is lined with vineyards. In this latter place, one stock-owner alone has some 200,000 sheep. Algodones, Corrales, Sandia, are all well-to-do towns on the river; and Santo Domingo, the Indian pueblo, is the picture of peaceful content. The Pueblos were thrashing their grain by driving goats and horses round in a circular inclosure. These Indians who have, ever since known, lived in towns, cultivating the soil and raising small herds, are to be wondered at for having retained their manners and customs so distinct from those of the Mexicans. Contented with little, they certainly have not much.

From the valley of the Rio Grande we went up the Galisteo Creek to the town of Galisteo, covering the country known as the Cerillos, and also the plateau running out to the north of the Sandia Mountains and east to the Placers. In this section are to be found large anthracite-coal beds, which will with the age of railroads become valuable. In the Cerillos are silver and galena deposits and an old mine of turquoise. Several of these mines, known to have been worked by Indian labor by the old Spaniards, are found through the country. In some cases the shafts are filled with brush; others are illy concealed with earth. Just west of the Cerillos is La Bajada Mesa, a volcanic plateau, through which the Santa Fé Creek has cut a narrow cañon. The principal point on the mesa is the Tetilla, a sharp cone, which many centuries in the past has overflowed the surrounding country with the molten rock, now covered with turf from the easily-decomposing feldspathic lava. There are two main routes from Santa Fé to the lower country in the vicinity of Bernalillo, Algodones, and Albuquerque. The one now little used, but formerly the stage-route, follows the general direction of the Santa Fé Creek, south of west to the edge of La Bajada Mesa; thence rising the mesa, it crosses it by a good road and descends by what is known as the La Bajada Hill, a steep, dangerous descent, particularly in its present condition. It comes to the river at Santo Domingo. The other route, known as the Pinos Ranch road, runs to the east of the Santa Fé Creek, strikes over on to the Galisteo Creek drainage, crosses the Galisteo Creek beyond Pinos Ranch several miles, and comes to the river in the vicinity of San Felipe. There are also two main routes to Fort Wingate and Northern Arizona from Santa Fé. Following the La Bajada Hill route to the foot of the hill, the right fork of the road leads to Peña Blanca, situated on the Rio Grande just south of the mouth of Santa Fé Creek; crossing the river here by a good ford, it runs through the foot-hills of the Valles Mountains to San Ysidro; thence, over a rolling country, crossing the Puerco Creek of the East near Cerro Cabezon, going north of Mount Taylor, passing Cross Spring, Willow Spring, and the Mexican town of San Mateo, it comes into Blue Water Ranch; from there to Bacon Spring and Fort Wingate; thence westward down the cañon of the Puerco of the West to the Little Colorado into Northern Arizona. This is one route to Prescott. From Wingate there is a second road running south over the Zuni Mountains to the Puebla of Zuni, down the creek of the same name; thence, crossing over to the White Mountains at Summit Spring, the road runs to Camp Apache. The second route to Wingate follows either route from Santa Fé to Albuquerque, crossing the Rio Grande there, the Puerco of the East at the bridge 6 miles above Quelites, running by Sheep Spring, El Rito, Laguna, Cubero, and McCarty's ranch, south of Mount Taylor, it joins at Agua Azul with the first-mentioned road. From just beyond McCarty's ranch a fork of the road leads off to old Fort Wingate, thence to Agua Fria, Ojo Pescado, and Zuni, thence to Camp Apache, or, branching at Deer Spring, to Prescott.

Santa Fé has been so often described that it is useless to refer to it further. While there a new triangulation-station, well weighted, was built on the hill near the meridian-mark and the points re-occupied for the development of the triangulation to the south and east.

The country assigned to the party to be surveyed after leaving Santa Fé lies south of the main stage-road as far as Vegas, thence north to latitude 35° 40′, thence east to longitude 104° 07′ 30″, thence south to latitude 34° 50′, thence west to the Rio Grande, an area containing approximately 6,600 square miles. This work was accomplished before our return, but, of necessity, with a delay of nine days in arriving at Las Animas.

The main rocky range, which breaks up just northwest of Mora into two ranges, the Santa Fé range and the Las Vegas range, with the Pecos Valley between them, loses its ridge-like characteristic at the break through which runs the present stage-road, built by Colonel Macomb, United States Engineers, in 1859. South of the road and east of the main Galisteo branch is a high plateau, more or less cut up by cañons extending to Cañon Blanco on the south and to the Pecos River Cañon on the east. The grazing on it is very fine. Just east of the Pecos rises another table-land, much broken up, extending between that stream and the Tecalote. From beyond this stream rises the Mesa Chupaines, through which the Gallinas cuts a deep cañon. Beyond the Gallinas it is a grand level plateau, extending to Ute Creek, cut through by the Canadian River and its tributary Mora Creek. Evidences of volcanic or eruptive action are found on nearly all of it.

The principal streams of this section of the country are the Pecos and the Canadian. The former drains an immense area. Taking its head in the numerous small lakes on the east slope of the Santa Fé range, it gathers these waters together with those of the Las Vegas range, the eastern slope of this latter range being drained by the Gallinas, which empties into Pecos beyond the mountains.

The foot-hills of the Santa Fé range run down just southeast of Santa Fé nearly to the Galisteo. The Arroyo La Java, the southern fork of the Galisteo, heads opposite the head of Cañon Blanco; the two constitute the terminal drainage-lines of the range west of the Pecos. The Conchas, a fork of the Canadian, rises entirely without the range in the plateau and, cutting a cañon down through it, debouches on the plain at the Rincon de las Conchas; thence flowing nearly due east it empties into the Canadian about six miles above Stone Ranch, known to the Mexicans as the plaza of Don Francisco Lopez.

The subdrainage-basin of the Cañon Blanco and Galisteo is very limited. To the south the greater portion of the water south of Cañon Blanco sinks in the plain, being cut off by the run running south of the Arroyo La Java and the above-named cañon. To the south of Galisteo Creek rises a new formation or succession of uplifts, not a continuous range, but rather spasmodic uplifts, which usually abound in mineral veins. The Placer, San Ysidro, San Pedro, Sandia, and Manzana Mountains rise from the Placers, each distinct in itself and together forming a group. The Sandia, running for 10 or 12 miles with the dip of the rock to the east, the western face being nearly vertical, the eastern slope smooth, have at their southern end the Cañon Tijeras. East of the Sandia, and separated from them by a broad, beautiful valley, lie the Placer Mountains on the north, then the Tuerto or New Placers south of them, then the San Ysidro, and on the southwest of these the San Pedro, a low line of wooded mountains. All of these have gold, copper, and iron in veins and deposits, and traces of silver and lead. Coal is also found in the vicinity. The placer-diggings are very fine. I saw several nuggets found in the Tuerto or new placer-diggings, weighing 2 or 3 ounces of very fine quality gold. The little mining now done there is by a very rude rocker or *batea*. No steps have been taken to form a reservoir of water; indeed, everything shows but the individual efforts of men who cared but to make a livelihood or had not the capital to properly work the placers. There was no work being done on the veins or deposits, and never had been much more than prospect-shafts. It is said, however, that prior to the Mexican war, at the little town of New Placer, there were some 4,000 souls living on the products of these placers; frightened away by the approach of the American Army, they never returned. One Mexican, the principal man of the town, stated, and his story was corroborated by the other old men of the place, that he once found a lump of gold which weighed 11 pounds 9 ounces avoirdupois. I give the story for what it is worth. He certainly had done so, or else had told the story so often that he, as well as everybody else in the town, believed it. The Ramirez lead or deposit—it is hard to tell which in its present unworked state—is a wonder in size. Prospect-shafts show it to be well defined by a wall-rock on at least one side. It runs with very slight dip to the east nearly 30 feet thick at the points of exposure. The country-rock is porphyrite. The ore is easily quarried; mainly of copper-carbonates, it carries quite a proportion of gold.

The San Ysidro Mountains should have mineral wealth from their formation, although no leads have been as yet worked. In every respect the section was the most promising we had seen during the summer. With the San Antonita, San Pedro, Cañon del Agua, and Agua Limpia Valleys running through it, furnishing the best grass we had during the season, with water enough for large sheep-herds, plenty of timber on the mountains, which will be of great value when the railroad is built, which will be forced to pass through this region or within 10 or 15 miles of it, as it is the only timber near fit for ties, the section is a valuable one, and it seems unfortunate that it is covered by land-grants, the Cañon del Agua and San Pedro, whose owners have so far left its wealth undeveloped.

In the San Pedro Valley and to the south of here, in the Manzana or Monte Largo range, we found fields which did not depend on irrigation, which is quite unusual. To the east of the Tuerto, San Ysidro, and Manzana Mountains extends the great dry basin, finely grassed for 8 or 10 miles from the mountains, but dependent upon the water therein to be utilized for grazing. At the little town of La Madera, at the northeast base of Sandia Mountains, was a saw-mill, at which they were making lumber of the timber from along the base and sides of these mountains. Four or five large sheep-herds were seen grazing in the San Pedro Valley. Nearly all the hay used in the towns Bernalillo, Algodones, Sandia, and Santo Domingo, and much of that for the Government corrals at Santa Fé, is drawn from here.

The most prominent point of the Manzanas is Mosca Peak, rising from the range with two sharp points, the southeastern one of which was used as triangulation-station. It will prove of great value in carrying the triangulation from Mount Taylor, Santa Fé range, and Las Vegas range to the south and east. The mountains are finely grassed, and game is very abundant. The range north of Mosca, to the Tijeras and Gutierres

Cañon has little strong character, being quite low and heavily timbered, broken up by branches of these cañons, as well as by Hell Cañon and Cedar Cañon, with their branches. Traces of copper are found throughout the range. Chilili is the only town of the range south of Tijeras within the area to be surveyed by the party, Tesuque lying just south of it. The equinoctial storm, which struck us while in this section on the 21st September, commenced with a cold driving rain, which turned into a snow-storm. East of these mountains extends the plain of Guadalupe, or, as it is sometimes called, the plains of Galisteo. It is a dry expanse of country, with no running streams, and but three springs, these near the mountains. Antelope Spring, the largest, is about 15 miles east of Mosca Creek. Here, as also at Buffalo Spring, 8½ miles to the north, there is a ranch. The other spring is but a black hole, from which the water does not run. It is known as Stinking Spring, and is situated about 10 miles north of east of Buffalo. The numerous bones of mules and horses bleaching on the plain around the spring show how bad the water is. The plain is unbroken from the mountains to the Pecos divide, excepting by the Cerros de Pedernal, the Cerrito del Lobo, and the Cerrito del Cuervo. Beyond these, indeed commencing with the Cerros de Pedernal, which are sharp, bare points of porphyritic rock, the divide runs to the north-east, connecting with the low hills south of Cañon Blanco. From Pedernal the Cañon Piedra Pintada runs eastward to the Pecos River, with a very uniform grade of 37 feet to the mile. It would be much preferable to the Cañon Blanco route, as a connection with a road running up the Canadian as far as Fort Bascom, thence up Pajarito Creek, crossing over the heads of Arroyo Cuervo and down the Tanques to an easily-bridged crossing, thence up Piedra Pintada, thence over to Abo Pass, thence to the Rio Grande. There is, to be sure, but little water in the cañon, but it could easily be obtained by wells. Nor is there more on Cañon Blanco. This for a connection between the proposed road of the thirty-fifth parallel and the Southern Pacific would be a very short and easily-graded route. The grade in Cañon Blanco is much heavier and not so uniform, the outcome at the head being quite steep. Between the two cañons the country is gently rolling. The divide west of the Pecos waters is covered with small timber, mainly piñon. At the Lagunas Coloradas, at the head of Cañon Blanco, water can nearly always be found, so also at the water-hole on the south side of the principal point of the Cerro Pedernal, just east of the Anton Chico and Fort Stanton road, about 100 yards and slightly above it. In Cañon Piedra Pintada in the wet season water is always found.

Near where the road from Pedernal crosses the Cañon Blanco, at the head of an arroyo running into it, is Aguaje Guajolotes, which almost always has water in it. Near the mouth of Cañon Piedra Pintada is the Agua Negra spring of permanent water. In the cañon the grazing is very fine; 15,000 sheep were seen between the Pecos and the divide. From there to within about 10 miles of the mountains the grass is very poor. Just below the mouth of the Piedra Pintada Cañon, or, as it is here called, the Cañon del Agua Negra Grande, is the town of Puerto de Luna, the most southern of the towns visited on the Pecos River. With its clean white houses nestling in the cañon of the Pecos, it is strikingly pretty. Just north of here, at a little opening in the cañon, down which flowed the Agua Negra Chiquita, are the scattered houses of the town of Santa Rosa. Above this the river passes through a cañon impassable to animals, opening at the deserted plaza of Esteros. Still farther north, where it opens again, are the towns of Colonias and Plaza Abaja, and at the mouth of Gallinas Creek is the town of La Junta. Farther up are La Cuera and Esteritos; immediately above the mouth of Cañon Blanco is Montosa, and 2 miles from there Anton Chico, the most important and largest town south of Las Vegas and east of Santa Fé. This, as Galisteo, is a radiating point for roads. From the north there is the main road from Las Vegas, which is the heavy freight-road. West of the Pecos is the San Miguel road, which crosses the stream at La Cuesta. Forking from this road is the Albuquerque road, which runs up over the mesa to the west, coming into Cañon Blanco near the lakes and town of Los Griegos, a small, scattered town on the north of the cañon. From this road, about half-way between Anton Chico and Los Griegos, branches the route via Pedernal to Fort Stanton, known as the dry route. Running to the southwest of the stream is the road to Puerto de Luna. East of the stream is the road to La Junta; another to Fort Sumner, branching from which, near Whittemore's ranch, is the route to Fort Bascom. Still farther north is the road over to the towns of Los Torres, Chaparrito, and Rincon de las Conchas. From Galiesto run the roads to Santa Fé to the north, and Fort Stanton to the south, there being two to the latter place, one by way of Buffalo Spring, the other by Stinking Spring; the former, branching before reaching Buffalo Spring, runs through the Cañon Gutierres to Albuquerque and the Rio Abajo country, at Buffalo Spring again branching, the western fork running in the foot-hills past Chilili to Fort Stanton, the other going to Antelope Spring or Ojo Berenda, from there to Stanton. The routes to the east and west from Galisteo are the road up the Arroyo La Java past the Lagunas Coloradas and Los Griegos to Anton Chico, the route up the Arroyo Cristobal over the mesa to San Miguel, thence to San José, 3 miles above. Following a branch-drain of the Cristobal past Los Fuertes and Aguage Abrego is the

route to Koslowskeys. Farther west is the route to Rock Corral and that to Santa Fé. To the west run the roads to Real de Dolores and Real San Francisco, and the route down the Galisteo to the Vaca, thence to Santo Domingo. The only roads not already mentioned between the Pecos and Rio Grande of importance within the section to be surveyed by the party and south of Santa Fé are the routes from Santa Fé, via San Marcos Spring, Old and New Placers, San Pedro, San Antonio, San Antonito, and Tijeras to Albuquerque; or, turning off at the mouth of the cañon to Peralta, the route through Cedar Cañon from Tijeras to Chilili, that through Hell Cannon, from Peralta and Isleta to the same place, that from Tijeras through Gutierres Cañon, past the Lagunas Coloradas, joining with the Galisteo and Anton Chico road to the latter place, and the route from Antelope Spring past Pedernal down Cañon Piedra Pintada to the Pecos. For distances on these routes see tables of distances to be published.

East of the Pecos, between the two large plateaux, at one time connected, lies the broad rolling plain broken by occasional mesas extending down the Canadian drainage. Along the Conchas are the Corazon, a high wooded dome, the Bareadero, a flat rectangular mesa, and other minor mesas. To the south of Corazon is El Cabre Mesa; southeast from there, Mesa del Pino; still farther south, Barejon, Churisco, Cuerro, and Cuerrito; these latter are at the head of Arroyo Cuerro, which rises in Churisco and Cuerro Springs and other small springs; running to the northeast, it enters a cañon, the mesas of which are much broken by other minor drains; sallying from here, it empties into the Conchas, rarely running water—a supply can always be had in the water-holes. Beyond the mesas of the Cuerro is the Mesa Riceo, the highest in the section; this divides the drainage of the Conchas from that of the Pajarito, an arroyo running from the south to the east of Mesa Riceo, and emptying into the Canadian near Fort Bascom. Of these isolated mesas, the Rica is the largest; rolling on top, it is 10 or 12 miles long. Three points of it were occupied for secondary triangulation, as were also Mesa del Pino, Mesa Cuerro, Cuerrito, and Corazon. The Cuerro just at the head of Cuerro Arroyo is the sharpest, best-defined point. South of this opening extends the great wall of the Llano Estacado, across the northern portion of which we worked for some days getting the drainage-lines of the Arroyo Juan de Dios and Alamo Gordo.

The main routes of communication in this section east of the Pecos are, first, the road from Los Vegas via Taylor's Ranch and Gallinas Spring to Fort Sumner; the route from Anton Chico past Gallinas Spring to Stone Ranch and Fort Bascom; the Buffalo road, nearly parallel to the northern edge of the Llano Estacado, running from La Junta; the route from Fort Union to Bascom, across the head of the Cañon Largo; and the route from Vegas down the Gallinas Creek. On the road to Fort Sumner, about 8 miles from the crossing of Gallinas Creek, is the Laguna del Alto de Los Esteros, at which there is usually water. At the Esteros, given on maps as Hurrah Creek, from the thirty-fifth parallel surveys, there is water in holes, as also at Los Tanos. Throughout this whole region the grass is wonderfully good, and numerous herds of sheep were seen, although not 1 per cent. of what the country would support. There is very little large timber in the whole of this region—almost none. The party reached Stone Ranch November 10. From there they proceeded up the Canadian for two days to the northern limit of the atlas-sheet, or rather a little beyond, to the mouth of the heavy cañon of the Canadian. There is a cañon of about 300 feet deep extending from the mouth of the main cañon. Beyond this is the main cañon, 800 to 1,000 feet deep. From the mouth of this the mesa wall runs westward to Mesa Chupainis and eastward to Ute Creek. Just north of here, indeed very near the mouth of the cañon, the country is covered with basalt. Below the mouth of the cañon, on the first slope or plateau, is another basaltic formation. About 2½ miles north of the mouth of the cañon comes in the Mora, a stream supplying nearly all the water of the Canadian. Also coming from the west, between the Mora and the face of the mesa, is the Cañon Largo, a narrow gorge, impassable in places to men on horseback.

Rising the mesa at the mouth of the cañon, we pushed north of east for 58 miles to Tequesquite, on a small drain, branch of Ute Creek from the west. Here we found encamped the topographer, who had not been with the main party since August 17.

The following day we started on our homeward march, running but a traverse line. Following up the Ute Creek 22 miles above Tequesquite, we came to where it emerges from the cañon. Entering the same, we still continued up it, till, forced by the undergrowth, we ascended with difficulty to the plateau above. Many sharp volcanic cones dotted the plain, which, gently rolling, extended far to the east. We pushed on to the head of the cañon, which is 20 miles long. The Cerritos del Aire, in which heads the Ute Creek, were in sight. They are a cluster of volcanic cones, with but little running water in the drains. Just to the east of these runs the old Kansas City freight-road, now unused. A short distance beyond them we reached the head of the Dry Cimarron, striking the Fort Union and Las Animas road, which we followed to Las Animas, reaching there November 24. All the country traversed between the Pecos and the head of the Dry Cimarron was very fine grazing-land. Although still considered dangerous on account of roaming bands of Indians, we saw none. From Dry Cimarron to Las Animas the grass was very poor, probably from the herds of cattle driven from Texas on this route.

At the head of Ute Creek, as well as on the Dry Cimarron, we found ranches. In and about the head of the latter stream is a very pretty section of grazing-land and some little arable land.

We had been in the field 166 days; during that time the party traveled 4,627 miles, surveying an area of 11,300 square miles; in this, 24 sextant latitude-stations, 94 mountain and mesa points for triangulation and topography, 160 three-point stations for the location of important points were occupied, 2,968 miles traverse line were run with stations or meander, 147 cistern-barometer, 1,767 aneroid barometer stations were occupied. The highest altitude reached was 13,393 feet, on Meigs Peak, Colorado; the lowest point was Las Animas, Colorado, a little less than 4,000 feet.

Too much credit cannot be given to Mr. Anton Karl and Mr. Niblack for the energy and ability with which both carried out the duties assigned them.

I desire to tender my thanks to the officers at Santa Fé and Fort Wingate, N. Mex., particularly Capt. Charles P. Egan, C. S., U. S. A, and Lieut. L. H. Walker, Fifteenth Infantry, for their prompt official kindness.

I am, sir, very respectfully, your obedient servant,

CHAS. C. MORRISON,
First Lieutenant Sixth Cavalry.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in charge.

APPENDIX F.

EXECUTIVE REPORT OF LIEUTENANT C. W. WHIPPLE, ORDNANCE CORPS, ON THE OPERATIONS OF SPECIAL PARTY, CALIFORNIA SECTION, FIELD-SEASON OF 1875.

PHILADELPHIA, PA., *April* 25, 1875.

SIR: I have the honor to report the following outline of the operations of the party of which I was in charge during the field-season of 1875. It was composed as follows: Frank Carpenter, topographer; Frank M. Lee, meteorologist; Sergeant Eugene Farnham, Twelfth Infantry, odometer recorder; 2 packers, and 1 cook.

Leaving Los Angeles, Cola., on the 28th of June, several days were spent in the vicinity of Wilmington to enable Mr. Carpenter to connect by a line of levels the southwest end of the Bates line with the bench-mark of the San Pedro Breakwater. This being completed, the party moved past the little settlements of La Bayonna and Santa Monicu, and at the foot of the range of the same names, along the beach to the Malaga Ranch, at which point an ascent and station were made on a somewhat prominent peak. The great difficulty so frequently encountered afterward, and which was so serious an obstacle to the progress of my work, met me here. Excepting a small, scant stubble-field of barley, there was literally not a particle of feed to be obtained for my animals, which were already suffering severely from unaccustomed work. I wished to stay at this ranch a couple of days, but I could not buy the permission for more than a single night. The following one, after a most trying march through soft, shifting sand, and over deep, dry gulches, we were even worse off, for we had, in spite of representations to the contrary, neither water nor grass. Finally leaving this shore, we succeeded in forcing our way through the chaparral, and camped on the summit, in the vicinity of which we made a topographical station.

Throughout my stay in these mountains, work was very much retarded by the almost constant existence of heavy fogs. The ocean was scarcely ever visible, but far away, clear and distinct, we could see the peaks of the various islands rising above the clouds. So intense was this fog that even the ordinary meander-work was accomplished with difficulty, and sextant observations were impossible.

Descending into the valley of the Simi, we occupied the extreme western point of the Santa Monica ranges and connected with several Coast Survey stations. Following the dry wash of the Simi, (called in this vicinity "Lost Palos,") we crossed the divide of the Susana range; made a station on its most prominent peak, and, keeping along the Conejo and Triunfo Creeks, finally crossed the San Fernando Plains, and camped, July 14, with your party at the Mission. A week well occupied in meandering the Little and Big Tujunga Creeks, in visiting the Charlotte mines, situated at the head of the latter, and collecting topographical details of this vicinity. Crossing the Arroyo Seeo, which your own topographers had already meandered, we kept along close under the San Gabriel range, with the intention of crossing it by what is known as the Wilson trail. This plan was changed in consequence of meeting Mr. Cowles, of Dr. Kamfp's party, who informed us that they had just returned from a triangulation station by that trail, which only ran to the top of the mountains, that the country beyond was impassable, and that Mr. Joy, of their party, was lost, and might possibly be found by going up the San Gabriel Cañon. With the intention of making such an

attempt, I moved on with all haste, and had the fortune to meet Mr. Joy at the entrance to the cañon. The information I succeeded in obtaining in regard to the possibility of finding grass was so exceedingly discouraging that I decided not to risk my animals by taking the San Gabriel trail, the details of this vicinity having already been collected.

Crossing by the Cajon Pass, we followed down the Swarthows Cañon on to the Mojave Desert, and camped near the mouth of Rock Creek. This stream meandered, we struck for Soledad Pass, and, occupying stations on the south side, marched straight down the Santa Clara Valley to San Buenaventura, on the sea-shore.

The Santa Clara rises in some springs and small mountain creeks near the mouth of the Soledad Pass, and a few years ago, it is said, was a continuous running stream. Now it is dry for much of its length. At Riley's Station, a few miles above the stage-crossing, the present occupant told me that in 1869 there were large lakes in this valley, both above and below him, and an abundance of water in the river. He then ran profitably placer-diggings in the range to the north. That year the water began to fall at the rate of an inch and a half per day, and he commenced to sink his well, which is now 80 feet deep, with a very scant supply of water. I was shown a great variety of ore specimens, including graphites, blue and green carbonates, magnetic iron; but no mines were then worked nearer than the Charlotte at the head of the Big Tujunga Cañon. With the exception of the Cumules Ranch, which consumes the waters of the Penn Creek in irrigation, but little cultivation is attempted in the valley above Santa Paula, which is some 16 miles from the sea.

We followed the San Buenaventura River to its junction with the San Antonio, and, passing through the pretty little village of Nordhoff, crossed the Topa Topa Mountains by a very rough trail, and reached the Cespe Creek. The scarcity of grass and the critical condition of my animals hurried my departure from a locality where the single man brave enough to strive there for an existence did all in his power to assist me; and I crossed the White Sandstone range, which incloses the north side of the cañon, by a trail which he indicated, making a station on one of its highest points from a camp on the summit, and, following Ray's Creek, moved round the base of Cuddy's Mountain, and joined you at Tejon August 15. Here my party was increased by the addition of Mr. Douglass Joy, assistant geologist. After your departure, and upon deliberations with Dr. Kampf, chief of triangulation, I made arrangements for the erection of a monument at Mount Pinis, and returned to the White Sandstone Mountains to complete from a point in this range, adjacent to the one already occupied by me, the triangle between that station, Mount Pinos, and Tehachipi Mountain.

As an example of the difficulty attending an instrumental work during the season, t may be said that after one day had been spent in cutting down trees, another followed, during which the fog and mist did not permit us to catch a glimpse of Tehachipi, and barely of Mount Pinos, though scarcely 10 miles away. Sleeping on the mountains, Mr. Carpenter and myself were fortunate enough to see both of our points, which soon after sunrise, however, were covered by the mist which rose from this valley, not again to be seen for the day.

With the intention of collecting the topography of the range north of the Santa Clara, and completing unfinished work, we then crossed Motor's Flat, where in a number of cavities in an immense rock we found some very odd Indian hieroglyphics and paintings, and following down the Hot Spring trail camped on the Cespe in the vicinity of the springs themselves. These were exceedingly interesting, and it is a source of regret that the bottles of water collected there were broken during their shipment to Washington. The flow of water comes from the base of the mountains, forms a very considerable stream, possesses a temperature of 195° at its point of emergence, and probably contains sulphur and iron.

Thanks to a multiplicity of stock trails, I was misled into attempting the cañon, and had the satisfaction of spending six days there, during which I crippled some of my animals, smashed one wheel of my odometer vehicle, and met with other mishaps. I succeeded in getting within about 5 or 6 miles of the mouth of the cañon, far enough indeed to see from the mountain-side into the open valley of the Santa Clara, only to find that farther progress was absolutely impossible and that I must retrace my steps.

Over immense bowlders, through pools of water deep enough to carry the mules off their feet, through a country where in the most accessible spots the soil had been stripped of the meager supply of herbage it perhaps once possessed, we struggled on and finally crossed the Topa Topa by the same trail we had used before, and, leaving Nordhoff on our right, camped at the Ojai. Our road from here to the Santa Paula took us around the base of the Sulphur Mountains, out of which run the Tar Springs, which frequently flow across the road, and in the heat of the day are soft enough to make travel difficult.

Some days were spent in Santa Paula, meandering the creek and occupying a very difficult point at its headwaters. The Peru then having been meandered for some distance from its mouth, I sent Mr. Carpenter and Sergeant Farnham to San Fernando, to collect some topographical details in the vicinity of the Pacoima Creek, and awaited their return on the Santa Clara.

Moving up the Castac Creek I then followed an excellent trail across the mountains to a point on the Peru near where I had terminated my meander before, and keeping to its headwater, passed the Los Alemos and Gorman's ranches, and reached old Fort Tejon, where I had left my supplies, on September 19. From here our march took us past Rose's Station, and along the foot-hills to the San Emidio, then round the edge of Kern Lake, through Bakerfield and across Sage-brush plains, which numbers of little pre-emption houses indicated a hope on the part of the inhabitants to reclaim, to a point on the sluice at the western extremity of this area allotted me.

I moved north from here under a broiling sun toward Posa Creek, and though this country was so barren that I begged from a humane ranchman at my first camp the corn-stalks which formed his shed-cover to prevent my animals from starving, he was sanguine enough to herd sheep there in large numbers.

When I arrived at his camp he was driving around an ill-conditioned horse, pumping up water from a well 90 feet deep, while his thousands of sheep were huddled together in bands under care of dogs, waiting their turns to drink; and when I left him in the morning he was similarly employed.

Following Posa Creek, in which water stands in occasional pools, we climbed the backbone of the Green Horn Mountains, and, camping on the summit, from a station looked down into the valley of Kern River. Here, as everywhere, was apparent the overstocked condition of the country; every vestige of grass seemed trodden out, even in spots almost inaccessible. By the most perfect road I have ever seen, we moved past the lumber-mill into the valley and up the river to Kernville, where a day was employed in visiting the Sumner mines, and where every courtesy was shown us by Mr. Burke, the superintendent.

We camped over night at the hot springs a few miles below, and then, following up Erskine's Creek, took a trail which leads us to the summit of the Pah-Ute Mountain. The mines and work here were carefully inspected, thanks to the extreme kindness of the proprietors, and a station made on the peak to the eastward. Passing through Clarasillo, we visited the John's mine and made a station on a beautiful point we called the "Crowned Butte," on the edge of this desert, and, keeping down Kelso Valley and along Cottonwood Creek, we crossed a divide and camped at the warm springs of Caliente Creek. Moving from here into Walker's basin, a station was made on Mount Breckenridge and an abandoned mine visited, and I then took my party into Caliente for supplies. From here our road lay along the line of the Southern Pacific Railroad in the Tehachipi Pass, and making a camp for a few days in the valley, we meandered Sand Cañon, Charlie Morris's Cañon, and Caché Creek, and made two stations in the range between Tejachipi and Kelso Valleys. The difficulties in executing nice instrumental work had been increased. Besides the mist and fogs, the wind blew constantly almost a gale, filling the air with dust and sand.

Crossing Little Oak Creek, we then passed by Desert Springs and Elizabeth Lake, and camped at Lopez Ranch, on the edge of the Desert, long enough to permit us to make an excellent station in the range north of Polvadera Pass and near its mouth. From Elizabeth Lake, I sent Mr. Lee into Los Angeles to assist Lieutenant Bergland in his meteorological computations. We then passed the head of Castac Creek, and, having made two stations in this range north of the Santa Clara, we crossed the hills, and following down a valley, passed Cow Springs and Gorman's Ranch and over on to the San Emidio Creek.

Here, November 2, for the first time during the season's work, we were detained by a very severe storm, which covered the mountain-side with snow. Moving due west, we made a station near the Paleta Ranch, and, descending into the valley of the Cuyana, followed it for miles through as barren a country as I had yet seen, and by very hard marches crossed to Lockwood Creek, and reaching the San Emidio again, moved on to the Plato. Here we visited the antimony mines, recently established, and of which great hopes are entertained.

For some miles the bed of the Plato ran in an exceedingly pretty valley, where we startled deer and quail from cover at every bend; but it gradually narrowed, until it became an absolutely impassable cañon, and we were forced to climb for hours with jaded, worn-out animals over immense hills. Scattering with pistol-shots bands of mountain-sheep, we climbed to the highest point, made a station, and descended over rolling foot-hills to the valley.

Striking from here across the plains, we made a direct march toward Caliente, and, climbing the hills by the old Bakersfield Road, reached that place and joined Lieutenant Birnie on November 13. After Mr. Klett's arrival with the other party, a week in Caliente sufficed to disband this expedition. I then conducted the trains to Los Angeles and stored the material.

It is a source of consolation to me that, before leaving this part of Southern California, I had the satisfaction of seeing grass springing up in the valleys and along the hills. Ocular demonstration was necessary to convince me of the fact that such could be the case, for in the six months my party had been in the field my animals had but once found feed (this on the summit of a high mountain) that I did not pay for. That

this country was formerly noted for its grazing is undeniable, and I took pains to gather from every source of information some explanation of this change. Mr. Cuddy, pointing to the hills opposite his house, near Fort Tejon, said that the bunch-grass which once covered them no longer grew there at all.

Another source of disquietude to those interested in the welfare of this section of our country, is the diminution in the supply of water. It is true that in many localities where the attempt has been made, notably on the plains of Los Angeles and San Bernardino, artesian wells have been successfully sunk and furnish a plentiful supply of water. Even at Bakersfield, at a depth of 260 feet, water has been struck. But the grazing sections can hardly depend upon these for their wants, and everywhere I found evidences that the creeks and springs were failing. The Santa Clara River and Posa Creek, and the springs which feed them, may be cited as illustrations; their gradual, steady subsidence indicating something more serious than a failure in a winter's snows.

As regards the springs, I was told that the sheep "trampled them out;" but acquitting them of this responsibility, they are undoubtedly inflicting an injury on this country of a very serious nature.

Very respectfully, your obedient servant,

C. W. Whipple,
Lieutenant of Ordnance, in Charge of Party.

Lieut. Geo. M. Wheeler,
Corps of Engineers, in Charge.

Appendix G 1.

METEOROLOGY AND HYPSOMETRY.—FIELD-SEASON OF 1875.—BY LIEUTENANT W. L. MARSHALL, CORPS OF ENGINEERS.

United States Engineer Office,
Geographical Surveys west of the 100th Meridian,
Washington, D. C., July 8, 1876.

Sir: I have the honor to submit the following summary of the barometric work of the past field season, and of the office-work in connection therewith. The observations and work performed have been of the same character as in 1874, and reference is made to the report upon this subject in the annual report of that year for information other than is contained herein.

The various parties of the California and Colorado sections of the expedition of 1875 were provided each with duplicate sets of instruments, comprising cistern and aneroid barometers, psychrometers, and pocket thermometers, and with the necessary books of record and printed instructions with reference to observations, instruments, and books. The barometers, psychrometers, and thermometers were made by James Green, of New York; the aneroids with attached thermometers by Casella, of London.

Comparisons of all instruments were made at Washington, D. C., with the standards of the United States Signal Service, and again at Pueblo, Colo., and Los Angeles, Cal., before final distribution among the various parties, and their initial errors of indices determined. Daily comparisons among the instruments of each party served as checks upon their indications and afforded the means of detecting changes in instrumental errors, and the errors of such instruments as were fitted with new tubes during the season. The corrections for capillarity in barometers were included in the errors determined, having first been corrected for approximately, by shifting the scale to agree with the computed effects.

The observations taken during the field season were mainly for psychrometrical purposes, the time spent in the field being too short, and the observations at any one place too few to be of much service in general meteorological investigations in a region where general climatological features are as well known as may be given by cursory observations.

For the California section two reference stations were established by the survey, one at Los Angeles, Cal., and another at Fort Mohave, Ariz. The altitude of the cistern of the barometer at Los Angeles was determined by a line of levels run from the United States Coast Survey tide-gauge at the Wilmington breakwater, by Mr. Carpenter, of this survey; that of Fort Mohave, Ariz., was carefully computed by Lieutenant Bergland, by referring barometrical observations there by daily and monthly means to corresponding observations at Los Angeles, and this determination was afterward checked and verified by referring to the Signal Service barometers at San Francisco and San Diego, Cal., and Santa Fé, N. Mex. Camps, where parties remained several days, were taken as reference stations for all observations made in their vicinities; the camps themselves being referred to the stations above mentioned.

In Colorado and New Mexico the cisterns of the United States Signal Service barometers at Santa Fé, N. Mex., and Colorado Springs, C. T., were taken as distance-points, and the temporary camps of the parties, as in California, taken as reference stations for all observations made in their vicinity during occupation.

Horary tables were secured for Los Angeles, Cal., and Fort Mohave, Ariz. The horary tables published by Colonel Williamson in his paper on the "use of the barometer, &c.," for stations in California, and that for Camp Independence, Cal., secured by your expedition of 1871, were also used as far as they were deemed applicable. In Colorado and New Mexico no additional horary corrections were secured, but those determined in 1873 and 1874 being applicable, were used.

The observations taken in the field were copied by the observers on forms adapted to their complete preparation for final reduction, avoiding errors in copying and transcribing again and again upon special computation sheets. When filled, these forms were forwarded, when practicable, to the office in Washington, D. C., for revision and reduction, the certificate of the chief of party that they contain true copies of the original observations being required.

In following out the system of observation and record required by the printed instructions published by the survey, a great number of observations at various points were secured and have been reduced.

Upon the receipt of the observations from the field, the records of the various instruments were carefully examined, and their relative indices of error determined at every comparison, and therefrom their absolute errors upon the standard of the United States Signal Service in Washington.

The hourly observations were then corrected for instrumental errors, reduced to 32° F. and to level, and after correcting erroneous or erratic observations revealed by plotting. Horary tables were formed for the reduction of isolated cistern barometer observations and for use in reducing the aneroid profiles. In forming the tables of horary corrections I have had the observations reduced to second level plotted, and have selected those days only when well-marked diurnal oscillations are exhibited.

The relative humidities were not computed for each observation separately, but the means of the temperatures and wet-bulb indications were taken at each hour for the entire series, and the resulting computed humidities for the differences of these means taken for use in the barometric formula. Single results are liable to be so erratic and unreliable, that it is supposed that this course would give a sufficiently near approximation with less labor of computation for use in the barometric formula.

In computing the altitudes of camps, &c., from cistern barometer observations, the full formula of Plantamour containing a term for humidity, and as represented by the tables in Williamson, has been used. In the reduction of aneroid observations the smaller terms of this formula have been omitted, since the aneroid differences of altitude are generally small, and from the construction of the instrument some of these terms necessarily do not apply.

The observations have been referred by divers means to corresponding observations at the base station. When a long series of observations have been taken, the observations have been referred by a mean of the daily means, or of the observations at 7 a. m., 2, and 9 p. m.

Isolated observations have been corrected for horary oscillations when suitable tables were known, and referred to the corresponding daily mean at the reference station; otherwise simultaneous barometric observations have been obtained by interpolation and an approximate mean daily temperature used.

Observations taken upon peaks have been referred, (save in a few instances where they have been compared direct with the initial reference stations) to temporary stations at their bases, the approximate daily mean temperature being used in the temperature term, this temperature being observed at the base station, and found approximately as follows for the mountain station: The camps of the ascending party (as a rule) were established at the limit of tree growth, where observations of the thermometer were taken at 7 a. m. and 9 p. m. on the day of the ascent before and after the occupation of the station. These observed temperatures have been reduced 3° F. for every 1,000 feet difference in elevation between this camp and summit, and taken in connection with the 2 p. m. observation on the peak for an approximate daily mean. Where a peak is high above the reference station, and for lack of fuel, cold will preven observation at night upon its summit, some such device must be inaugurated for securing approximate daily mean temperatures. The temperature will necessarily always be observed near the hottest part of the day, and will give results the more erroneous the higher the peak is above the reference station. The changes in temperature must take place principally near the heating body, *i. e.*, the earthy surface; and especially in the excessively dry atmosphere of the West, where a conservator of heat in the shape of aqueous vapor is wanting, the air directly in contact with the earth undergoes great fluctuations in temperature, during the day giving ranges of climate temperature not at all commensurate in effects with the less horary oscillations of the barometer, whereas, if there be quite a thick and wide stratum of air between the summit of the peak and the reference

station not in contact with the earth, the actual mean temperature of the entire stratum varies but slightly, if at all, during the 24 hours, unless disturbed by abnormal warm or cold currents; so that while the observed temperatures near the surface would when plotted, during say a month or a year, show well-marked daily maximum and minimum, the mean temperature of the thick stratum would show nearly uniform changes of temperature from season to season, but slightly affected by diurnal oscillations. This would seem but a natural consequence of the fact that in a dry climate, where but little heat is made sensible by the condensation of aqueous vapor in the formation of clouds and rain, and still less is absorbed by the dry air, the entire diurnal oscillation in temperature is due to the actual heating of the particles of air by contact with the heated earth, which heat, taken by the air, may disappear by radiation or be expended in work in expanding the particle and overcoming the resistance to its upward motion, leaving but comparatively little sensible heat, carried by connection, to be distributed throughout the great body of this stratum. If this surmise be correct, not only is it necessary to obtain the daily mean temperatures for use in the barometric formula, but the means for a longer time, if practicable.

It would be interesting to find by experiment the limit of time for which the mean observed temperature, taken in connection with the observed height of the barometer corrected for horary oscillation, would give the best results.

Corrections for difference in *phase* of abnormal waves or for abnormal oscillations have not been directly attempted. As far as practicable, however, observations at points where altitudes are required, especially at semi-permanent stations, have been referred to two or more reference stations and the results weighed in accordance with the known general directions of atmospheric waves and the distance of the point whose altitude is sought from the reference stations estimated in the direction of this wave motion. This supposes that the position of the wave between the two reference stations is an inclined plane, which is true only within small limits compared with the area covered by an entire wave at any given instant, but this seems the only means at our disposal by which we may readily and approximately eliminate the effects of abnormal disturbances from the resulting altitudes, when, as must necessarily be the case in the thinly-settled west, observations must be referred to distant points in other phases of disturbance, and when the observations are not at points sufficiently numerous to determine the barometric gradients.

Since the middle of December the following work has been performed:

Cistern-barometer stations computed	930
Aneroid-barometer stations computed	5,013
Hourly observations recomputed and plotted, days	270
Horary tables deduced	14
Cistern-barometer altitudes copied into permanent record-books, and indexed	2,424
Aneroid-barometer altitudes copied into permanent record-books, and indexed	8,696
Total number of altitudes computed from barometric readings since 1871	11,125

All of the barometric work has been re-examined and such results as are considered most useful have been arranged for publication with Vol. II.

The computation shave been made by Assistants F. M. Lee and George M. Dunn, and privates William Looram and John F. Kirkpatrick, Battalion of Engineers, except Lieutenant Bergland's observations, which were computed under his own supervision at Los Angeles, Cal.

Respectfully submitted.

W. L. Marshall,
First Lieutenant of Engineers.

Lieut. Geo. M. Wheeler,
Corps of Engineers, in charge.

Appendix G 2.

ON THE METEOROLOGICAL CONDITIONS OF THE MOHAVE DESERT.

United States Engineer Office,
Geographical Surveys west of the 100th Meridian,
Washington, D. C., February 10, 1876.

Dear Sir: I have the honor to submit herewith a report upon the meteorological conditions of the Mohave Desert.

During the past five years observations upon the daily temperatures were made at the two military posts of Fort Yuma and Fort Mohave, both in the Colorado Valley; and to these military authorities thanks are due for information furnished. I hope

that this report may furnish some interesting points, as the greater portion of the Mohave Desert was until a comparatively recent date a *terra incognita*.

This report treats of the winds, rain-fall, cloud-bursts, sand-storms, electrical phenomena, hot winds, temperature of air, river, and soil, relative and absolute humidity, and ozone. Numerous comparisons with other countries have been added, in order to elucidate more clearly the specific character of this region.

Very respectfully, your obedient servant,

OSCAR LOEW.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in charge.

There exist probably but few regions on earth where two totally different climates are separated by a single mountain range, as in Middle and Southern California, where the uniform sea-climate of the coast-strip, with comparatively small variations in temperature, forms a most remarkable contrast with the climate on the other side of the gigantic chains of mountains, the Sierra Nevada and its southern continuations, the San Bernardino and Jacinto ranges, which represent the backbone of the State of California.

The state of humidity, the direction of wind, the electrical condition, the daily oscillations in temperature, how far different are all these conditions on the west and on the east side of those mighty elevations which separate the Mohave Desert from the fertile coast!

In regard to the winds of the Mohave Desert, it is a striking fact that southeast winds are by far the most prevalent in summer time. It is also easily observed that the clouds and summer rains come from that direction. This observation was confirmed, on our arrival at Fort Mohave, by the hospital-steward of that post, who attended to the meteorological observations for the past three years. The great prevalence of these winds in Northern Texas, Southern New Mexico, and Arizona, was recalled to my memory; these same winds producing there the summer rains.

That this moisture-carrying current comes from the Gulf of Mexico, and is the continuation of the great equatorial current which, like the equatorial marine current, is a consequence of the earth's rotation, and flows from east to west in a width from 28° south latitude to 28° north latitude, cannot be subject to doubt.

By the development of the high summer temperature of those countries, the air-current deviates, upon its arrival in the Mexican Gulf, from its original westerly direction to the northwest, and appears therefore as a southeast wind. That this stream of air must contain a great deal of moisture, may be inferred from its passage across the warm and extensive oceanic area between Africa and Central America. Although deprived of the greater part of moisture after its flowing across Texas, New Mexico, and Arizona, it still carries enough moisture as far west as the Mohave Desert, to produce occasional summer rains there; but at the backbone of California this influence is completely broken; the wind, now deprived of its moisture, is forced into a different direction, and no summer rains fall on the California coast. Here, on the contrary, prevails the northwest wind, which saturated at a comparatively low temperature with moisture, and passing over the much warmer continent, becomes drier; its relative humidity sinks rapidly; hence no rain can fall. However, when in the winter months the power of insolation is weakened, the land cools off, then the aqueous precipitates become extensive and the coast country covers itself with verdure.

In winter time the northwest winds also prevail over the entire Mohave Desert, but having lost most of their moisture on the passage across the high ranges, bring but rarely rain or snow in the desert. The absolute humidity, or rain-producing powers of the northwest wind, must naturally fall far below that of the southeast monsoons, on account of their respective temperatures.

While the summer rains in the Mohave Desert fall chiefly in great cloud-bursts that are always accompanied by electrical phenomena, neither is the case on the coast; thunder is at least there a very rare occurrence. The phenomenon of cloud-bursts is doubtless produced by the alternating position of hot, deep, and sandy valleys and steep, high ranges; the reflected heat of the former shifts the tendency of the clouds to a condensation to rain upon the extreme point, and these, approaching the somewhat cooler mountain-chain, must discharge their moisture at once, and sheets of water come down with such force that fragments of still uncondensed clouds are carried along. We witnessed this interesting phenomenon in more than one case; the clouds had the singular appearance of a lake-surface reflecting the light like liquid water.

The rains falling principally upon the mountains, rarely in valleys, it is not surprising that the rain-fall at Forts Mohave and Yuma is exceedingly small, both these posts being situated in the low and hot valley of the Colorado River. The following table, taken from the records of these posts with permission of the authorities, shows the rain-fall in four years:

Fort Yuma.	Inches.	*Fort Mohave.*	Inches.
1870	2.71	1870	3.07
1871	0.78	1871	2.01
1872	3.34	1872	3.02
1873	3.84	1873	3.04

If the rain-fall in the neighboring ranges had been measured, the results obtained would doubtless be three to four times as high. More than once did we see extensive rains in the mountains when not a drop fell in the adjacent valley, and were surprised on three occasions by heavy rains; once falling 1.06 inches of water in four hours.

Sand-storms, hot winds, and whirlwinds, the latter producing columns of sand 100 to 200 feet high, are not infrequent, while they are quite rare in the coast counties. The hot wind (simoon) is a most disagreeable feature; it continues sometimes until late at evening, with a temperature of 108° F. The sand-storms produce certain electrical phenomena; sparks were drawn by us one night from a blanket that was covered with a stratum of sand deposited by a sand-wind.

Analogous to other deserts, the climate of the Mohave Desert is in summer time generally very hot and of great dryness. In connection with the latter, stand the great daily variations of temperature.

In the annexed table are placed side by side some of our observations with those of Rohlfs made at Rhademes, an oasis in the Sahara Desert, and a comparison will show how closely both climates agree. The highest temperature Rohlfs observed at Rhademes was 43°.9 C. = 111° F., August 11, 1865. This was next to Shimmedru in the Oasis Kauar, the hottest place he struck in his travels through Africa; and at this locality he observed on a series of afternoons 53° C. = 127° F. At Mursuk, where he remained from November, 1865, to April, 1866, he observed as the highest temperature 36°.1 C. = 96°.9 F., (March 12, 1866.)

According to Humboldt, the temperature of the Llanos of Caracas seldom rises above 98°.6 F., although these plains are situated near the equator.

The highest temperature our party observed in the Mohave Desert was 116° F., on the 6th of August, at Stone's Ferry, in the valley of the Colorado River in Southern Nevada. However, the temperature reaches sometimes still higher limits. Mr. Jennings, who lived for nearly eight years at Saint Thomas, a small settlement on the Muddy, 24 miles from the Colorado, stated that in 1871 the thermometer rose in the shade every afternoon for three weeks in succession to 123° F., and on one occasion to 127° F. A temperature of 122° F. was also repeatedly observed at Fort Mohave. The temperature at night during the summer-months sinks frequently to 70° F., but does not fall often below 90° F., particularly when the air is in motion.

The hottest portions of the Mohave Desert are the Coahuila Valley, (altitude—100 feet,) the Lower Virgin River Valley, (altitude +1,300 feet,) Death Valley, (altitude −200 feet,) Panamint Valley, (altitude +1,400 feet,) the Saline Flats of the Mohave, (altitude +1,200 feet,) and the Colorado River Valley up to 1,200 feet altitude. While the four months June, July, August, and September are prominent by a very high temperature, the remaining eight months have a very moderate climate, and ice and snow have been repeatedly seen on the Saline Flats of the Mohave in January. Warm winters, however, exist on the Lower Colorado and in Coahuila Valley, in which latter wild palms form an ornament of the oasis.

As regards the mean temperature of the hottest months, it was calculated for July, 1873, in Fort Mohave to be 100°.9 F., but for this calculation three observations served, taken at 7 a. m., 2 p. m., and 9 p. m. It is evident that the 7 a. m. observation is not a correct element in this calculation, as the temperature shortly before sunrise is considerably lower than at 7 a. m. We arrive clearly much nearer to the truth if the lowest temperature in 24 hours be introduced into the calculations of the mean. In July, 1873, were observed as the monthly means the following figures:

7 A. M.	12 M.	9 P. M.
91°.4 F.	100°.2 F.	98°.7 F.

If we take as the mean of the lowest temperatures admissible in July = 75° F., and calculate then the total monthly mean, we obtain 93°.6 F., which still is a very high degree.

The mean temperature of the hottest month in—

	Degrees C.	Degrees F.
Cairo, Egypt	29.9	85.8
Madras, India	31.8	89.2
Abushar, Persian Gulf	34	93.2
Llanos of Caracas	31.5	88.7
Shimmedru, Sahara	35 to 36	95 to 96.8
Rhademes, Sahara	32.1	89.6
Ghadames, Sahara	32.4	90.3
Fort Mohave, Colorado River, Arizona	34.2	93.6

We see from this comparison that July at Fort Mohave counts among the hottest periods of the globe.

A table taken from the records of the post by the kind permission of the authorities may find here a suitable place. It shows the monthly mean of all the 7 a. m. observations, that of the 12 m. and of 9 p. m. in 1873.

	7 A. M.	12 M.	9 P. M.
	F.	*F.*	*F.*
January	47°. 9	63°. 8	56°. 7
February	47 . 6	62 . 3	53 . 6
March	58 . 6	81 . 9	68 . 4
April	64 . 0	83 . 0	69 . 7
May	69 . 1	88 . 3	78 . 2
June	81 . 7	104 . 1	89 . 3
July	91 . 4	110 . 2	98 . 7
August	85 . 6	101 . 4	88 . 2
September	78 2	102 . 0	88 . 2
October	64 . 0	86 . 3	74 . 0
November	54 . 1	77 . 0	67 . 1
December	45 . 1	58 . 2	51 . 2

As in barren countries the development of heat by insolation on one hand is just as powerful as the loss of heat by radiation in absence of sunlight on the other, December is here observed to be the coolest month, and the sudden transitions from May to June and from September to October.

How insignificant, compared with these conditions, appear the changes of temperature between winter and summer on the coast at Santa Barbara! The following table showing this is taken from the Santa Barbara Press:

Month.	Monthly mean.	Month.	Monthly mean.
1872.	*Fahrenheit.*	1872.	*Fahrenheit.*
January	51°. 00	July	68°. 00
February	54 . 00	August	69 . 00
March	57 . 00	September	67 . 00
April	60 . 00	October	64 . 00
May	63 . 00	November	60 . 00
June	69 . 00	December	63 . 00

In Los Angeles, some 30 miles from the coast, the contrasts are already increased, July reaching a mean temperature of 75° F., January 52° F.

The temperature of the soil is generally above that of the air in sunshine, but this is more the case in barren stretches of the desert than anywhere else; indeed, temperatures of 150° F. of the soil can easily be observed when the air has but 112°. While, however, the surface loses much by radiation during the night, and has at sunrise that of the air, the earth in a foot depth retains still a high degree of heat. I found it one morning still 94° F., when at the same time the surface and the air had but 73° F.

In regard to the temperature of the Colorado River, it may be mentioned that from middle of July to middle of September it was never found below 78° F., and not above 82°.5. How small this variation compared with that of the air!

The temperature of the Rio Grande in Colorado and New Mexico was found in 1874 to be, within small variations, 63° F. from July to October. Humboldt found the average temperatures of Rio Apure and Orinoco during the hottest months to be 27° C., or 80°.6 F.

In regard to the relative humidity of the air, great variations may, *a priori*, be expected where the daily extremes of temperature are great. Thus, the relative humidity August 6 was, at sunrise, 0.526, (saturation = 1.0,) while at 3 p. m. = 0.093.

Rohlfs* observed as the mean relative humidity in August at Ghadames (Sahara) = 0.330, and in July = 0.275. The lowest relative humidity was found in November, 1865, at Murzuk, (Sahara,) at 0.07, (dry bulb = 82° F., wet bulb = 55° F.)

But not only the *relative* humidity is subject to a great range, but also the *absolute*. While this was observed in the Colorado Valley after a heavy shower to be increased to 15 grams per cubic meter, it amounted at dry weather only to 6, sometimes 3. Still lower figures, however, were obtained in the fall of 1874 in Northern New Mexico, (see Annual Report of Explorations and Surveys west of one hundredth Meridian for 1874.)

*His extensive meteorological reports are published in Peterman's Goegr., Mitthelungen, 1872.

As a general rule, we see, with the *decrease* of the absolute amount of moisture, an *increase* of the daily difference of extremes, as shown in the following table:

Locality.	Date.	Absolute humidity.	Difference of extremes.
			Fahrenheit.
Cottonwood Islands	July 12	7.8	44°.00
	July 27	12.9	15 .00
Stone's Ferry	Aug. 6	6.0	39 .00
	Aug. 12	15.1	18 .00
Rhadames in the desert Sahara, (Rholfs)	Aug. 15	11.7	27 .00
	Aug. 18	13.6	20 .00

In some cases the differences of daily extremes stood nearly in inverted proportions to the *square* of absolute humidities; in other instances, especially when two cases with widely differing absolute humidities were compared, the differences of the daily extremes stood nearly in inverted proportion to the *simple* absolute humidities. A law expressible by a mathematical formula can only be found, however, after a long series of very careful observations. It is natural that only observations made at one and the same locality and in the same season can be compared with each other.

In regard to the ozone, none, or but very weak reactions, were obtained when the temperature rose above 106° F., which failure is either due to the volatilization of the iodine from the test-papers prepared with iodide-of-potassium starch, or to the real absence of ozone; however, during cool nights moderately strong reactions were obtained in midst of the desert.

Thermometer and psychrometer observations in the Mohave Desert.

Locality.	Date.	Sunrise.		12 m.		3 p. m.		Sunset.		Remarks.
		Dry bulb.	Wet bulb.	Dry bulb.	Wet bulb.	Dry bulb.	Wet bulb.	Dry bulb.	Wet bulb.	
		°	°	°	°	°	°	°	°	
Cottonwood Island, Colorado River Valley, 40 miles above Fort Mohave.	July 21	69.0	64.4	106.5	72.2	104.0	72.1	85.5	72.0	
	July 22	63.0	56.5	106.0	73.4	107.0	73.0	91.2	70.1	
	July 24	90.2	72.0	99.2	74.5	104.1	76.2	......	....	A hot east wind blew in the night 23d–24th of July.
	July 26	73.0	70.2	....	....	98.0	75.3	90.0	74.0	A heavy thunder-storm occurred in the night 25th–26th of July.
El Dorado Cañon, Colorado River Valley.	July 27	81.0	68.5	....	....	96.0	74.5	93.5	70.2	Few clouds; moderate wind.
	July 31	78.0	61.5	102.3	69.0	106.0	72.5	105.0	68.3	A hot wind blowing until 9 p. m.
	Aug. 1	81.2	58.0	....	....	....	....	......	....	
Stone's Ferry, on the Colorado River, Southern Nevada.	Aug. 6	75.0	62.0	112.0	75.3	114.0	74.1	107.0	69.8	Hot wind in the afternoon.
	Aug. 7	83.5	63.8	105.0	72.3	112.0	73.2	106.2	69.5	Moderate southeast wind; partly cloudy.
	Aug. 8	88.0	67.2	108.0	77.4	113.1	74.9	100.0	73.5	Clouds in southeast; hot wind in the night.
	Aug. 10	80.6	70.0	....	....	104.2	76.8	97.0	73.5	Rain on the 9th, and in the night from 10th to 11th of August.
	Aug. 11	73.2	73.2	84.5	75.0	93.0	76.9	90.0	78.5	Cool breeze all day.
	Aug. 12	82.0	74.0	97.8	77.2	98.0	77.1	89.0	76.2	Cool southeast wind; clear sky; sand-storm in evening.
	Aug. 13	79.0	67.5	98.0	75.0	101.2	72.0	......	....	Sky clear.
Rhademes, in North Africa, (Sahara).	Aug. 2	73.1	58.1	....	....	102.0	70.8	84.0	64.9	Observations by G. Rohlfs in 1865.
	Aug. 3	75.9	57.7	....	....	106.0	82.0	89.9	70.7	Do.
	Aug. 4	79.0	60.9	....	....	106.9	75.0	91.9	70.8	Do.
	Aug. 5	77.0	59.0	....	....	108.0	77.7	93.0	70.8	Do.

APPENDIX H 1.

REPORT ON THE GEOLOGY OF A PORTION OF SOUTHERN CALIFORNIA, BY PROF. JULES MARCOU.

LOS ANGELES.—The hills which surround Los Angeles, forming a vast amphitheater open only on the west, are composed principally of friable sandstone of a yellowish-gray color, with some intercalated layers of sandy clay and limestone of the same color. These rocks, which have all the appearance of real *molasse*, can be studied to the best advantage in the trenches which have been dug on the side of the old *presidio*, or fort, which overlooks the town on the north; and also by following the trenches of the aqueduct and the cañon of the Rio de los Angeles or Rio de Porciuncula, after leaving the town, as far as the valley of San Fernando. The strata are all much elevated, and dip in a south-southeasterly direction, at an angle varying from 30 to 35 degrees. The thickness of the sandstone-beds varies from 1 to 5 feet, but beds are nowhere found of sufficient hardness to furnish good building stone, on account of the friability of the sandstone, which is rapidly decomposed by the action of the atmosphere.

Fossils are very rare, with the exception of the bones of *Cetacea*, which are in a bad state of preservation, and it is difficult to obtain good specimens. On the hill of the *presidio* fragments of the cast of a small gasteropod are sometimes found in the sandy clay; of this not even the *genus* can be determined.

On the road from Los Angeles to Cahunga Pass, descending the northern declivity of the hills, before reaching the plain of the Balonas or Bayona, we find several scanty petroleum-springs, and the limestone in the vicinity of the springs is strongly impregnated with asphaltum. The petroleum, or bitumen, when dried in the sun, becomes hard, and is then known by the name of "brea" to the Mexicans, who use it as a covering for the roofs of their houses and as a pavement for sidewalks.

The hills of Los Angeles begin at the southeast of the lagoon, and of the Balona or Bayona ranch, rising at the east-northeast toward the cañon of the Rio de los Angeles or Rio de Porciuncula, which cross them; they then rise in gentle acclivities against the granite of the Sierra Madre, not far from the ranches of the San Gabriel Mission; finally, they again descend toward the south, and next turn once more to the east, and form the small basin of El Monte. Their height is small, and varies from 50 to 300 feet above the bottom of the valley of Los Angeles.

PLIOCENE ROCKS OF LOS ANGELES.

The sandstone rocks of Los Angeles may be considered as a brackish deposit of an estuary, or of lagoons, subsequent to the formation of the valley of San Fernando, where they do not exist. The sierras of Santa Monica and San Fernando had already undergone a movement which had obliged the sea to recede more to the south and to the west. The formation of this sandstone is evidently quite recent, and, as it is placed between the Miocene rocks of San Fernando and the Quaternary alluvial rocks of the bottoms of the valleys, it must be regarded as being of the age of the Pliocene Tertiary.

Fish-bearing limestone rocks of Los Encinos.—Below the molassic sandstone rocks of Los Angeles we find a group of limestone rocks whitish, chalky, and containing a small quantity of magnesia, stratified in rather thin layers, the entire thickness of which is from 100 to 150 feet. These white limestone rocks are found in the hills which face San Gabriel and along the road between San Gabriel and the San Fernando Valley.

In these limestone rocks, especially in the upper portions, we meet here and there with remains of fishes, such as scales and vertebræ, generally in a bad state of preservation.

Denudations have carried away these limestone rocks in which fish are found in the cañon of the Rio de los Angeles or Rio de Porciuncula, and likewise at the beginning of the San Fernando Plains; they reappear, however, in the San Fernando Valley, where they form a large portion of the bottom of the valley, and a part of the first "counterfort" of the mountains which surround it, beginning a mile and a half to the west of Cahunga Pass, as one goes toward Los Encinos. At the ranch of Los Encinos these limestone rocks attain their greatest thickness, which is nearly 200 feet; and they contain in their upper portions, close by the houses of Mr. Eugéne Garnier's ranch, a large quantity of fossil-fishes, large bones, vertebræ, and ribs of *Cetacea*, fossil-plants, *Crustacea*, and, it is said, even birds; also a quite common bivalve mollusk—the *Pecten Peckanii* Gabb.

These fish-bearing limestone rocks of Los Encinos belong to the Miocene Tertiary rocks, of which they form the upper portion. As regards their age, they may be compared to those at Oeningen, on the banks of the Rhine, near Schaffhausen, Switzerland, or to those of the quarries of Aix, in Provence, France. They are a deposit of brackish, almost fresh, water, notwithstanding the presence of a small *Pecten* and of *Cetacea*. It has not, as yet, been possible to collect the fishes in sufficiently large numbers, or to examine them in such a manner as to be enabled to obtain correct ideas with regard to the ichthyological fauna of Los Encinos.

At the ranch of Los Encinos the direction of the dip of the strata is north-northeast, at an average angle of 15°. These strata consist chiefly of light, grayish, pale-yellow, or chalky-white limestone rocks, in layers of a thickness varying from 2 to 3 feet; they are easily divided into slabs, with numerous dendritic impressions. The fossils are found chiefly in the upper portion of the group. These fish-bearing limestone rocks have evidently formed the entire bottom of the beautiful valley of San Fernando, as is shown by the hillocks or isolated mounds which have been left here and there in the plain by erosions, and on which remains of fossil-fishes and the *Pecten Peckanii* are found. I refer particularly to the mound by the side of the stage-route which leads to Santa Barbara.

THE SIERRA OF SANTA MONICA.

The San Fernando Valley is closed on the south by the Sierra de Santa Monica. The center of this sierra is between the ranches of Los Encinos and of Santa Monica, or San Vicente, is formed of a gray syenite, composed of fine particles, passing to a true granite, and easily decomposed by atmospheric action. Dioritic rocks here and there intersect the syenite, and from massive dikes toward the crest of the sierra, on the south side of the chain. On these syenites rest large grained sandstone rocks, scarcely ever more than 250 feet in thickness, and covered in concordance of stratification by the fish-bearing limestone rocks of Los Encinos. These sandstone rocks are sometimes asphaltic, and contain some fossils, especially the beautiful *Pecten Veatchii* Gabb, and *Pecten Whipplei*, new pieces. Beautiful specimens of these two large *Pectines* have been collected a little to the west of Los Encinos, at the Malaga ranch, by Lieut. C. W. Whipple, of the Ordnance Corps, who had charge of one of our exploring parties.

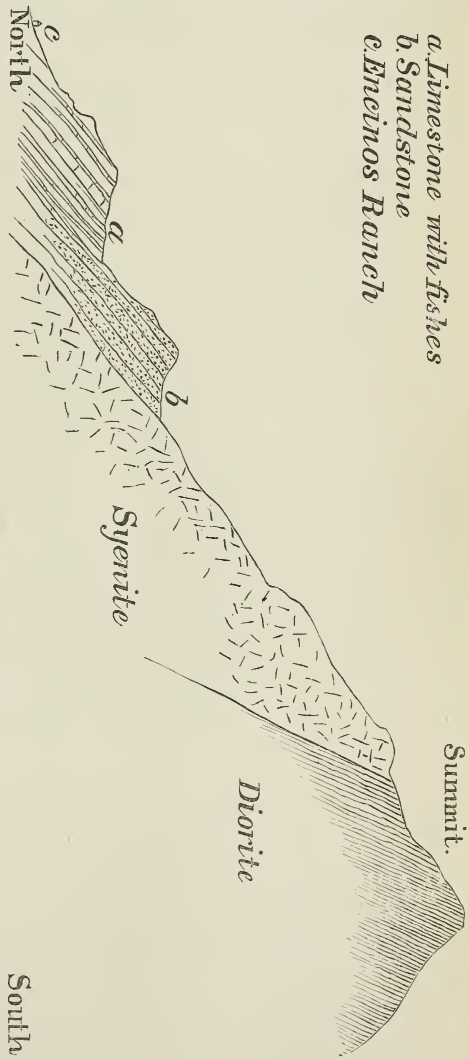


FIG. 1.—Section of the Santa Monica range near Encinos Ranch.

At the side of the principal house of the Encinos ranch, at the top of an isolated eminence, which overlooks the basin of mineral-water, numerous remains of vertebræ, ribs, and head-bones of an enormous fossil cetacean are found. There also are found the upper beds of this formation of white fish-bearing limestone. These beds are arranged in the form of calcareous lenticular nodules inclosed in silex. These nodules are from 2 to 3 feet in diameter, and, when opened, are found to contain fossil-fishes, fragments of bones of *Cetacea*, or plants.

The Sierra de Santa Monica runs from west to east, and strikes perpendicularly against the granite and pegmatite of the Sierra Madre, on the other side of the cañon of the Rio de les Angeles or Rio de Porciuncula. This cañon itself has been formed through this sierra, which rises rapidly in the eastern part, after leaving Cahunga Pass. From a height of from 500 to 600 feet the crests of the sierra suddenly rise to an altitude of from 800 to 1,000 feet on either side of the cañon of Los Angeles.

Hills of sandstone and of fish-bearing limestone, identical with the beds of the section near Los Encinos, fill the eastern extremity of the San Fernando Valley, and rise against the granite of the chains of the Sierra Madre at the entrance of the large

cañon of the Big Tuhunja or Tujunga. Towards the point of contact with the granite and the crystalline metaphoric rocks the Miocene Tertiary strata are much raised and contorted; the direction of their dip is easterly, opposite to that in which the Sierra Madre runs. We follow these mountains or Tertiary hills which form the counterforts of the Sierra Madre, from which they are separated by a kind of large ditch all along the eastern and northeastern extremities of the San Fernando Valley as far as the entrance of the Pacoima or Pacoña Cañon. There they end abruptly; erosions and denudations have destroyed them for a distance of 2 miles along the foot of the Sierra Madre, which here bears the name of the Sierra Pacoña or Pacoma; afterward these same Miocene strata are again met with before one reaches the Grapevine Cañon.

SIERRA MADRE, PACOÑA OR PACOIMA CAÑON.

The sides of the Pacoima Cañon are perpendicular, and it runs through gray granite rocks, gneissoid in some parts, with serpentinous metamorphic rocks and crystalline limestone at the entrance of the cañon. These rocks are the same throughout the length of the Sierra Madre chain, from the Cajon Pass Cañon, where I observed them in the spring of 1854, to the San Gabriel Cañon, in the Big and Little Tujunga Cañons, at La Soledad, or Williamson's Pass, and at the San Francisquito Pass. This gray granite, composed of fine particles, is the same granite as that of the Sierra Nevada, of which the Sierra Madre is a prolonged spur in the shape of a bayonet-like fault. This fault, or rather this bayonet-like rupture, of the primordial crystalline rocks, occurs between Tehachipi Pass and the Cañada de las Uvas or Cañon of Fort Tejon. The Pacoima Cañon, 4 miles to the east of the San Fernando mission, is narrower, deeper, and more zigzag than the San Gabriel and Tujunga Cañons. Four or five miles from its issue in the San Fernando Plain it becomes quite impassable, in consequence of deep, perpendicular cataracts which bar it entirely.

FIG. 2.—Plains of San Fernando, (near the village.) *a*, Miocene sandstones; *b*, Gray clay; *c c*, Quarternary; *d*, Metamorphic; *e*, Granitic rock; *f*, Modern rocks, Arroyo and Cañon de Pacoima.

I give below a drawing of the geological section to the left of the arroyo, at the place where the Pacoima Cañon issues into the San Fernando Valley.

The crystalline metamorphic rocks are from 100 to 120 feet in thickness; they form the entrance to the cañon, and are covered halfway up by a very heavy Qauternary drift. The arroyo of Pacoima has carried away much of this drift, which is very coarse, with rounded and quite heavy blocks; it may be examined all along the banks of the arroyo in cliffs or bluffs which have an elevation of 60 feet, quite perpendicular to the bed of the arroyo. This Quaternary drift evidently indicates a very large *cone of dejection** at the issue of a cañon which existed here during the Quaternary period. This cone is very well marked, more to the northwest, at a distance of a mile from the

* See torrents of the Upper Alps, by Surr ell, page 11; "Torrents des Hautes Alpes, par Surrell, page 11."

cañon, where superb remains of it are seen plastered, as it were, against the foot of the Sierra Madre.

The Tertiary-molassic strata dip towards the foot of the Sierra Madre—that is to say, to the north-northeast, which is a proof that the Tertiary strata have not been dislocated and uplifted by the Sierra Madre, but by another system of upheaval prior to the last upward movement of the Sierra Madre, which took place during the Quaternary period. The mass of Tertiary rocks which is nearest to the Sierra Madre is composed of a gray clay, which fills the bottom of a valley or kind of ditch, extending parallel to the Sierra Madre, all along the foot of the metamorphic rocks.

GEOLOGY OF THE VICINITY OF THE SAN FERNANDO MISSION.

Just north of the San Fernando mission there is a line of hills, having an elevation of from 150 to 200 feet above the mission; they are composed of limestone and sandstone identical with those found at Los Encinos, on the other side of the San Fernando Plains. The fish-bearing limestone rocks, however, are less thick than at Los Encinos, but they retain the same lithological characteristics, such as nodules of silex with chalcedony, and, as at Los Encinos, scales, vertebræ, and other fragments of fossil-fishes are found here, together with fossil-plants, in a bad state of preservation. The sandstone is coarse and hard, of a gray color, and in certain places it becomes a true conglomerate.

The direction of the dip of all the strata is to the north-northwest, at an angle of from forty to forty-five degrees; the heads of the strata run from northeast to southwest. Near the Lopez and Bernardi ranches, numerous specimens of the *Pecten Cerrosensis* Gabb are found in the sandstone, together with a new species similar to the *Pecten Deserti* Conrad, which I call the *Pecten missionis*, in honor of the San Fernando mission.

Grapevine Cañon.—In the eastern part of the Sierra of San Fernando, which is called Monte de Pinos on account of the pine trees which cover it, 3 miles to the north of San Fernando, on the right-hand side of the road which leads to the tunnel, the Tertiary rocks reappear toward the foot of the Sierra Madre; they rise higher as we approach the Sierra of San Fernando, which is entirely formed by them. At the points of contact of the molassic Miocene strata with the granite and pegmatite of the Sierra Madre in the Grapevine Cañon, the sandstone beds are very asphaltic in certain parts; and in consequence of folds and ruptures of the strata small springs of petroleum or mineral oil are found. The asphaltum flows over rocks, and in certain parts we find a real covering of pure asphaltum or Mexican "brea," which extends over several square yards around the springs. The rock has been bored unsuccessfully in the hope of finding petroleum, and the following is the geological section at the spot where the bore has been made. After reaching a depth of 50 feet the lead entered the pegmatite and remained there.

The sandstone is very friable, nearly of a bluish-gray color, like the molassic rocks of Switzerland, and often becomes a true conglomerate, or "nagelfluh;" it is impregnated with a considerable quantity of asphaltum. The strata are often very much dislocated, raised almost perpendicularly, inverted and folded, while close by they are almost horizontal. Yellow spots of oxidized iron are often seen in some of these beds of sandstone and conglomerate.

Fossils are quite frequently found, although generally in a bad state of preservation. Fine specimens of sharks' teeth are found, of the genus *Carcharodon*, probably the *Carcharodon rectus* Agassiz; also specimens of the *Fusus*, *Pecten*, *Tellina*, *Lucina*, &c., all of which indicates a Miocene-Tertiary fauna. In general, in the Grapevine Cañon the direction of the dip of the strata of the Californian "molasse" is south southwest, at an angle of 45°.

THE SAN FERNANDO SIERRA.

Following the San Fernando road to Lyon's Station or Petroleopolis, almost as soon as one enters the cañon to the right of the road in the direction of the Grapevine Cañon, superb folds in the strata of the Miocene sandstone rocks are seen. The direction of the dip of these molassic sandstone rocks is south, at an angle varying from 10° to 16°; the following is the geological section:

As we go higher up in the cañon a repetition is seen of the same strata of sandstone, conglomerate and fish-bearing limestone, in consequence of the numerous foldings to which all this Miocene formation was subjected at the time when the dislocations and elevations of the San Fernando Sierra took place.

The San Fernando tunnel.—When we reach the southern extremity of the tunnel the sandstone rocks are found still more massive; they here appear in the form of superb blue molassic rocks, with indistinct stratification, in enormous beds of from 15 to 20 feet in thickness. Here and there, scattered at different heights throughout these rocks, calcareo-sandy nodules are found, containing numerous fossil-shells, and forming the genuine shelly sandstone or *muschelsandstein* of the Swiss geologists. The following is a list of the principal fossils which I have found in the *muschelsandstein*, the

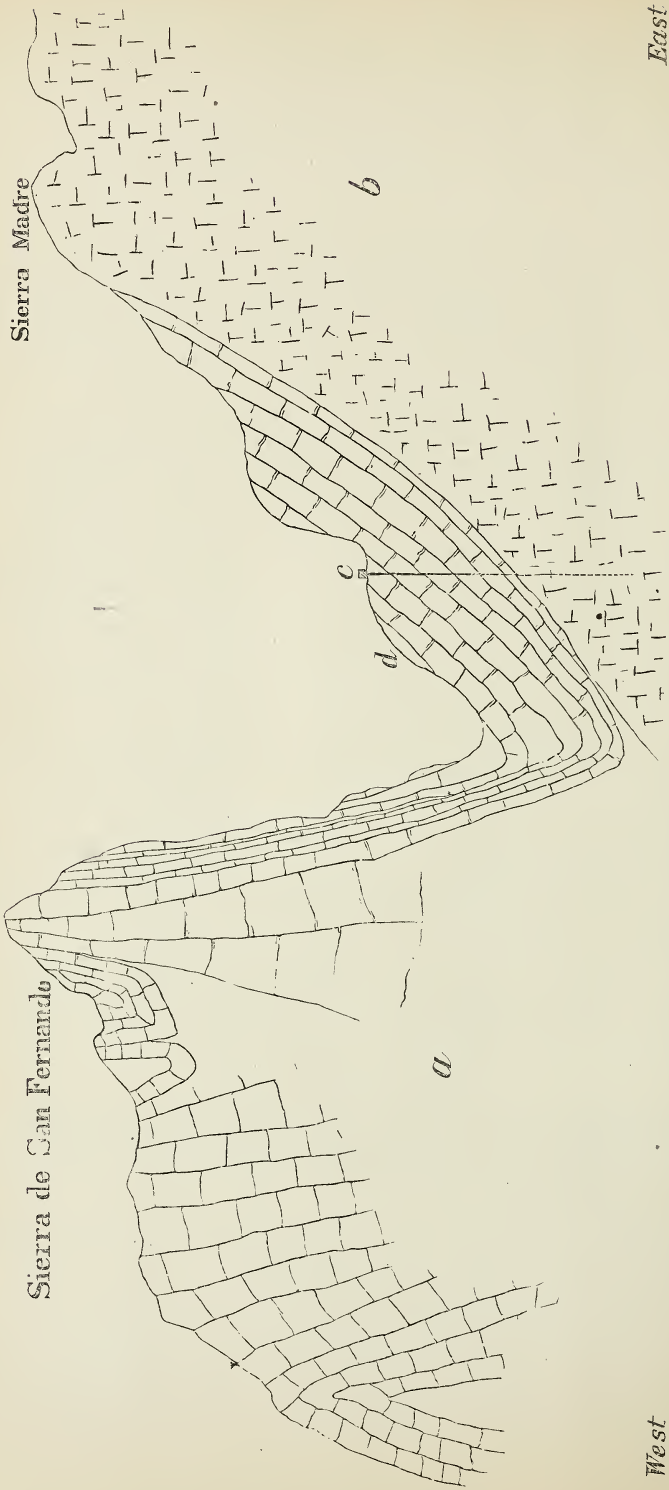


FIG. 3.—Section at Grapevine Cañon.—*a.* Miocene sandstone; *b.* Granite and pegmatite; *c.* Oil-well; *d.* Asphaltum.

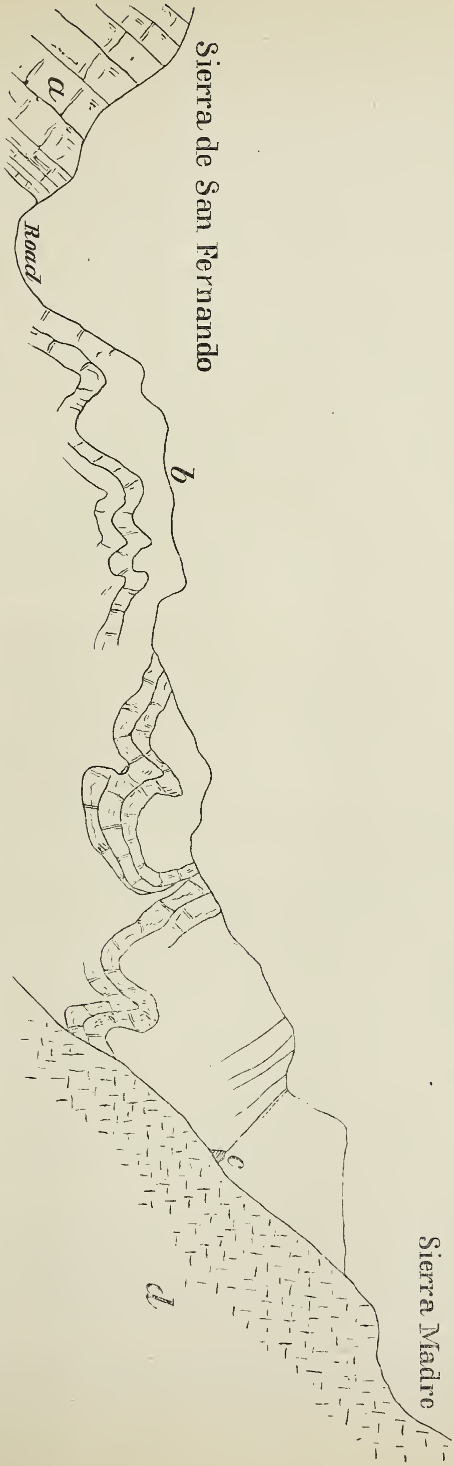


FIG. 4.—Entrance of Grapevine Cañon.—*a.* Limestone with fossil fishes; *b.* Yellow and blue sandstone; *c.* Oil-well; *d.* Granite and pegmatite.

appearance of which calls to mind the marine Miocene fauna of the *Helvetian* group of Switzerland and Suabia: *Neptunæ Humerosa* Gabb, *Turritella in—cd*, *Venus pertenuis* Gabb, *Callista Voyi*(?) Gabb, *Schizothorus Californicus*, n. sp.; *Pecten cerrosensis* Gabb, *Pecten Fernandii*, n. sp., very large and beautiful; *Cardium Californianum* (?) Conrad, and *Lucina Richthoferi* Gabb. In consequence of the extreme dryness of the climate and of the dust which results therefrom, the Miocene sandstone rocks of the entire San Fernando Sierra seem to be of a gray color. If a quarry is opened, however, it is seen that the real color of these molassic rocks is a pale blue; and the whole formation presents a general lithological, stratigraphical, and paleontological aspect which reminds one to such an extent of the Miocene "molasse" of Switzerland, as seen from Lausanne to Freiburg, Berne, Lucerne, Zurich, and the Lake of Constance, that I have often thought myself in Switzerland while really in California.

The San Fernando Pass.—As we approach the summit of the pass, after passing the Tall House, the strata become more and more inclined, until at the summit the inclination attains an angle of 60°, the direction of the dip being always southerly. It is also remarked that the molasse, the beds of which are from 10 to 15 feet thick, contains pebbles disseminated here and there in the sandstone. These pebbles finally become so numerous that the strata become a true conglomerate or "*nagelfluh*," similar to the "*nagelfluh*" of Righi, Rosenberg, the Emmenthal, and Appenzell, in Switzerland. Half a mile from the summit of the pass, descending toward Lyon's Station, we find a considerable mass of sandstone and conglomerate rocks of a dingy yellow color, 200 feet in thickness. The direction of the dip is southerly, or rather a little west of south. The direction of the dip of the strata does not change until we reach the secondary chain, only a mile this side of Petroleopolis, or Lyon's Station. The direction of the dip then changes to the north, or rather a little east of north, at an angle of 20°. We must remark that the road from San Fernando to Petroleopolis is very near the point of contact of the San Fernando Sierra with the Sierra Madre, and hence it follows that the inclinations of the strata are slightly different from the normal inclinations of the most western portions of the Sierra, in consequence of numerous plications and set-backs caused by the obstacle of the Sierra Madre.

ASPHALTUM AND MINERAL OIL NEAR SAN FRANCISQUITO RANCH.

Six miles to the west by south (ouest-sud) of Lyon's ranch, or San Francisquito ranch, precisely on the crest or arête* at the point of division from the San Fernando Sierra, there are two springs of petroleum-oil on each side of the summit of the mountain. On the north side Mr. Lyon's petroleum-spring is also known by the name of Pico's Spring, while that on the south side bears the name of Temple's Oil-Wells.

Before reaching Pico's Spring we cross two ridges of mountains, very abrupt on the south side, as are the greater part of the mountains of the San Fernando Sierra. These mountains are formed of huge mas es of molassic sandstone, of conglomerate, (*nagelfluh*,) numerous strata of which are thoroughly impregnated with asphaltum, and whose entire thickness varies between 1,500 and 2,000 feet. The direction of the dip of all the strata is toward the bottom of the Santa Clara Valley; that is to say, to the north, a little west of north, at very variable angles, between 20, 85 degrees, and even the perpendicular. Under these asphaltic sandstones, strata of arenaceo, marly schist mingled with rather thin beds of sandstone and limestone, intercalated here and there in these schistous clays, are seen to crop toward the center of the Sierra, and the petroleum-springs bubble up at the points of contact of these clays with the masses of sandstone and asphaltic conglomerate. These springs are not abundant, for two very simple reasons: first, they are at the very summit of the Sierra, and there are no basins to fill them; and secondly, the climate is an extremely dry one. During the very short rainy season these springs increase in volume and the petroleum is much more abundant. If these beds of sandstone and asphaltic conglomerate could be flooded, a large quantity of petroleum could be obtained. The only hope of obtaining a good and sufficient flow of this oil is by means of artesian wells bored at the bottom of the Santa Clara Valley. There, at a great depth—between 2,000 and 3,000 feet—there is some prospect of reaching the supply of petroleum and of its flowing in a rich and abundant stream.

Hitherto all the boring has been done in the worst localities that could possibly have been selected. Wherever a few insignificant petroleum-springs gave speculators the hope of making a sudden fortune, they went to boring at once, without thinking of the future. Whoever wishes to succeed must leave the vicinity of the Sierra Madre and the summits of the San Fernando Sierra, and go to the valley of Santa Clara or to that of San Fernando. There will be a better prospect, however, at the bottom of the Santa Clara Valley.

*The arête of a mountain is defined by Bescherelle as a curved line which usually separates the principal declivities of a chain of mountains where the highest peaks are found.

(The height above the level of the sea, measured by my friend, Mr. Francis Klett, is 2,260 feet.)

On the other side of the Sierra, looking then toward the south, are the springs and the bored well of Mr. Temple. The rocks present the same folds and contortions as at Pico's Spring; only the direction of the dip of the strata is to the south, at an angle of from 15° to 25°.

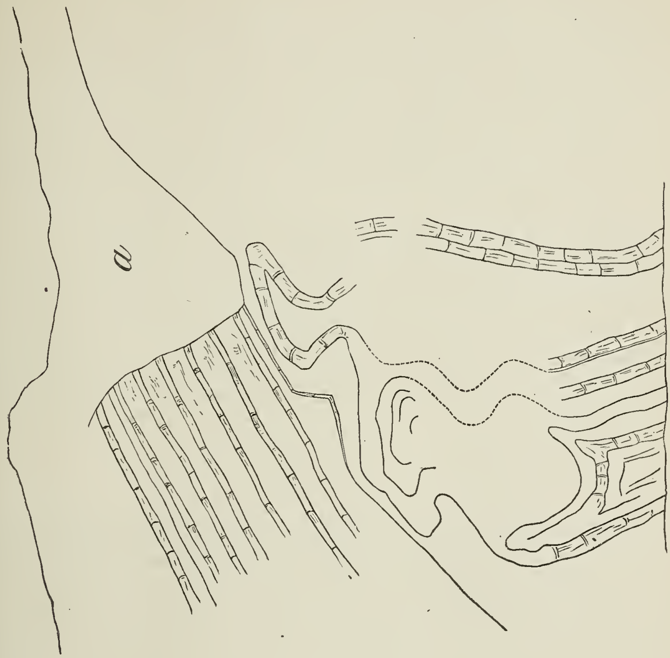


FIG. 5.—Pico's Spring.—*a* Asphaltic sandstone covered with vegetation.

If there is no hope of ever finding abundant springs of mineral-oil in the San Fernando Sierra itself, there is at least a prospect of getting magnificent and very rich quarries of asphaltum. These quarries will certainly one day be worked with the most satisfactory results. In the vicinity of the San Francisquito ranch the sandstone contains fossils, the most abundant of which is the *Pecten Cerrosensis* Gabb.

San Francisquito Pass.—The plain from the San Francisquito ranch, as far as Moore's Station, is composed of fine sand, of great thickness, which forms the entire bottom of the valley, and indicates that large rivers must have descended from the passes of Soledad and San Francisquito; and there is some reason to suppose that at the commencement of the modern period the Santa Clara Valley was the outlet of a part of the Western Rio Colorado.

A mile to the east of Moore's Station we again meet with the Miocene sandstone or molassic rocks, more or less inclined in directions varying from north to west and south. However, the westerly direction seems to prevail.

Before reaching the stage-station, doleritic trap-rocks, interstratified in the blue molasse, are found on both sides of the road, but particularly on the right. The molasse is then somewhat metamorphic, and its argillo-arenaceous schist becomes a lustrous black schist, similar to the fishy schists of Glarus or to the "flisch" of the Alpine geologists. The reader must not be surprised if I constantly remind him of the great lithological resemblance between the Tertiary rocks of California and those of Switzerland, Vorarlberg, and Bavaria. It is unusual to find so many points of comparison and similarity at such great distances from each other on the terrestrial globe. The conditions of the deposits must evidently have been the same in California and in Switzerland. The Sierra Nevada, or its prolongation, the Sierra Madre, performs the same part as the Alps in furnishing the materials which were deposited in the Californian and Helvetic Tertiary seas. The Tertiary rocks, both sandstone and schist, come to an end at Humphrey's ranch, where they are very much raised, some even to

the perpendicular, and some strata are even inverted. Suddenly, immediately after leaving the sandstone schist and dolerite, we find ourselves before a granite wall, which rises abruptly from 100 to 150 feet above the Tertiary rocks. This is the Sierra Madre, with its gray granite, consisting of fine particles, its pegmatite, its veins of quartz, its green and micaceous schist, and its old diorites. All at once the San Francisquito Cañon, which until now has been pretty wide, except near the dike of dolerite, becomes narrow and very sinuous, like the granitic cañons of San Gabriel, Tujunga, Pacoima, and Soledad. The directions of the crests or summits of the mountains also change abruptly, and instead of running from east to west, as in the San Fernando and Santa Monica Sierras, they run from south to north. Between Humphrey's ranch and the summit of the pass there are three parallel ranges of mountains running from south to north. The Delano ranch is situated in a little valley between the first and second of these ranges. After passing the valley of Lake Elizabeth we come to a fourth granitic range, known by the name of the Sierra de Liebre, which borders on the Californian Desert. These four ranges of the Sierra Madre are of unequal heights, the highest being in the locality where the "col" of the pass is found. The valleys which separate them, moreover, are of very different widths. The first two are the narrowest, while the valley of Lake Elizabeth is comparatively wide and open.

Origin of the name California.—Lake Elizabeth extends from east to west, and an extremely violent west wind blows there night and day, scarcely ceasing for a single instant; it is a dry wind, and its heat, which reminds one strongly of the air of a hot oven, has evidently given rise to the name California. The Mexicans or Spanish-Americans, who first came to this country by land *via* Sonora or New Mexico, soon remarked this temperature and this very peculiar climate, which has nothing in common with the three divisions which they had adopted, until that time, for Mexico, viz, *tierra fria*, *tierra templada*, and *tierra caliente*, *i. e.*, cold country, temperate country, and warm country; and they very properly called this country, so different from the three others, *tierra california*, that is to say, country hot as an oven.

SIERRA LIEBRE AND CALIFORNIA DESERT.

After crossing the Sierra Liebre, which separates the valley of Lake Elizabeth from the great basin or California Desert, if we follow the east foot of this granitic sierra, we several times cross wide river-beds, which are hollowed out in the sand, and through which not even small brooks now run. These dry beds indicate that at no very distant day—for one would suppose that the water in them gave out only a few days ago—large rivers descended from the Sierra Madre, or rather from that part of the Sierra Madre which is called the Sierra Liebre, discharging their waters into the great valley of the Dry Lake, where is now Willow's Station. The climate of Southern California has evidently undergone great changes in modern times. The sand of the desert covers this entire basin, which is a genuine American Sahara. Nevertheless, two miles to the east, before reaching Liebre's ranch, we again meet with the Tertiary sandstone, with the conglomerate, which here forms a counterfort to the Sierra de Liebre.

The strata dip to the south-southeast and north-northwest, at an angle varying from 15° to 30°, showing here and there the synclinal line of the strata. These sandstone rocks, which are of a gray and sometimes of a reddish color, are seen all along the road from Liebre ranch as far as Gorman's ranch, at the entrance of the cañon of Fort Tejon or Cañada de las Uvas. I was unable to determine the exact age of these Tertiary rocks, in consequence of a very long and painful journey in the month of July, when the weather was excessively hot. It is possible that some of the strata are of the Miocene epoch; I am, however, rather inclined to regard them as Eocene rocks. Where was the strait or passage through which the Tertiary sea communicated from west to east across the Sierra Madre and the Sierra Nevada? I have not been able to recognize it. It was evidently neither through the San Francisquito Pass, nor the Cañada de las Uvas or cañon of Fort Tejon, nor through the Tehachipi Pass. The Tejon Pass is the only one which I have not visited, but toward this all the Tertiary rocks to the east and west of the pass seem to run; and it was probably through this pass that the Tertiary sea, which covered the entire western portion of California, penetrated across the granitic chains into the great basin of the California Desert. This communication, however, possibly took place through the valley of the Rio de Peru, the water passing by the south foot of Mount Pinos and flowing into the great basin in the comparatively low mountains which are found between Liebre ranch and Gorman's ranch.

Cañada de las Uvas.—The Tertiary rocks in the vicinity of Gorman's ranch, which are very much uplifted and which dip to the west toward the Sierra de Liebre at an angle of 60°, are crossed by dikes of dolerites and euphotides, the real *gabbro* of Tuscany. The summit of the pass of the Cañada is on these euphotides, with yellow sandstones, and Tertiary, whitish, limestones. As soon as we descend we come to the granite of the range, which runs to the east of Lake Castac; and then the entire cañon of Fort Tejon runs through the granitic and crystalline rocks, gneiss; and a mile and a half this side of Fort Tejon we find a large dike of grayish-white crystalline limestone,

more than 100 feet thick. This is real marble, and runs from north-northwest to south-southeast. All this cañon is formed of gray granite exactly like the granite of the Sierra Madre and the Sierra Nevada, intersected here and there by dikes of milk-white quartz, dikes of rose-colored feldspath, and dikes of diorite. Sometimes, in place of the granite, we find gneiss and mica-schist, very much bent and twisted in all directions.

Tertiary rocks in the vicinity of Fort Tejon.—At the outlet of the cañon into the plain of Tejon's ranch, we find Tertiary rocks composed of a heavy mass of clay, more or less sandy, with some thin strata of sandstone and limestone intercalated at different heights of the mass. The Tertiary rocks stand against the Sierra, and rise only to one-half the height of the mountains which overlook the cañon. Some fossils are found in the sandstone, at the very entrance of the Cañada de las Uvas; but, as these fossils are much more numerous and in a better state of preservation three miles farther east, as one follows the foot of the mountains, at the *Arroyo de los Alisos,* (Alder brook,) or *Arroyo del Rancho Viejo,* (Old Ranch brook,) I am going to give a detailed section, with a list of the fossils collected in this locality.

The corral and the ruins of the Rancho de los Alisos are situated on the Quaternary drift, which is not very thick. Immediately afterward we come to hills of trachyte, trachytic conglomerate, and dolerite, which form the basis or first counter-fort of the mass of mountains. These eruptive rocks are the same as those of the Cañada de las Uvas near Gorman's ranch. They seem to have raised the Tertiary strata very much. These latter dip to the south-southeast, toward the foot of the mountains, at an angle varying from 60° to 80° and 85°, almost perpendicularly at the spot where there is a fault in the bottom of the principal lateral ravine to the east of the arroyo. At the place where the section was taken, on the right bank of the arroyo, the eruptive rocks form four small ranges of hills, which gradually rise to a height of 350 feet above the plain of Tejon ranch.

Immediately after passing the fourth hill, going up toward the mountain, we come to an abrupt bluff, which at first sight seems to be formed of drift. One soon sees, however, that the numerous rolled and much rounded pebbles that are met with are much flatter, and rocks whose composition are very different from that of those which constitute the ordinary Quaternary in the cañons, and the cones of dejection of the cañons of Tejon Pass, Las Tunas, La Pastorina, and Las Uvas. These rolled pebbles, moreover, are imbedded in a gray sandy clay of great hardness; finally, the whole is very much raised and dips in a south-southeasterly direction. This kind of argillous conglomerate forms the basis of the Tertiary rocks of the region about Fort Tejon. Toward the top of the hill, instead of this conglomerate, we find gray clay, containing here and there intercalated strata of calcareo-arenaceous sandstone; some are entirely calcareous, while some other strata consist of pure sandstone. These calcareo-arenaceous strata vary from 1 foot to 2½ feet in thickness; they dip to the south, at an angle which is very much inclined, and which even reaches the perpendicular.

At the bottom of the hill which separates the fifth hill or eminence from the sixth, we find a well-defined fault; the strata of fossiliferous sandstone now dip to the north, at an angle of from 45° to 50°, and the beds on each side of the ravine do not correspond. Having reached the summit of the sixth hill, we see a small valley, with a gentle declivity, which lies at the point where the stratified Tertiary rocks form a junction with the granite and other crystalline rocks of the group of the Fort Tejon Mountains. These Tertiary rocks are, approximately, from 250 to 300 feet thick. All the strata of sandstone and arenaceous limestone contain fossils in greater or less abundance; some are even full of them, and form a real *Lumachella;* thus, there are strata which might be called turrilitic beds, to such an extent do the *Turrilites* abound in them, reminding one of the ceritic limestone of the basin of Paris.

In consequence of the hardness of the rock, it is difficult to obtain complete specimens of fossils; although they are in general well preserved, it is very difficult to collect anything more than fragments. Dr. Horn, the surgeon at Fort Tejon, has made a good and numerous collection of these fossils, which has been described by Mr. Gabb in the first two volumse of the "Paleontology of California," published by that State. After having visited the locality explored by Dr. Horn, and having studied the geology of a portion of Southern California, I cannot adopt the opinion of Mr. Gabb, who considers this formation as cretaceous, and particularly resembling the Maastricht beds of Central Europe. I was not able to find a single cretaceous fossil, nor even any true cretaceous generic forms, in this entire formation; and I am altogether of the opinion expressed by Mr. Conrad, many years before Mr. Gabb, in volume 5 of Pacific Railroad Explorations, pages 318, 320, *et seq.*, who, judging from certain fossils found in an isolated block at the entrance of the Cañada de las Uvas, has very judiciously referred these rocks to the Eocene-Tertiary formation. I go even further. I think that the rocks of the Arroyo del Rancho Viejo of Fort Tejon belong to the superior Eocene epoch, and that they are of about the age of the "coarse limestone or calcaire grossier" of Paris. The fauna of Tejon reminds one very much of the fauna of the sands of Anvers, near Pontoise, and of the sands of Gregnon, near Versailles. The following is a list of the

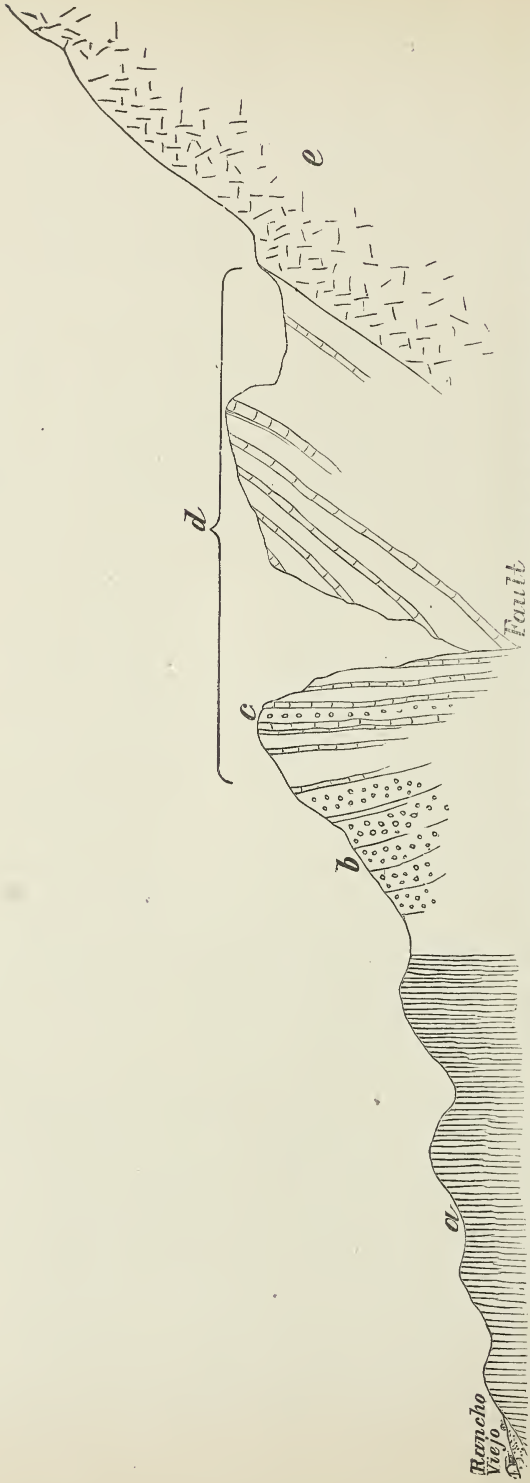


FIG. 6.—Section of Arroyo del Rancho Viego, near Fort Tejon.—*a*. Trachyte and dolerite; *b*. Clay with sand and flat pebbles; *c*. Syenite in clay; *d*. Clay with beds of limestone very fossiliferous, and some sandstones; *e*. Granite, crystalline rocks.

fossils which I collected at the Arroyo de los Alisos, near Fort Tejon : *Fusus* (*Hemirfusus*) *Remondii*, Gabb ; *Tritonium Whitneyi*, Gabb ; *Trit. Californicum*, Gabb ; *Trachytriton Tejonensis*, Gabb ; *Olivella Mathewsonii*, Gabb ; *Fasciolaria ficus*, Gabb ; *Mitica Uvasana*, Gabb ; *Lunatia* (*gyrodes*) *Conradiana*, Gabb ; *Neverita globosa*, Gabb ; *Never secta*, Gabb ; *Turritella Uvasana*, Gabb ; *Galerus Excentricus*, Gabb ; *Ringinella Pinguis*, Gabb ; *Tellina ovides*, Gabb ; *Tell. aqualis*, Gabb ; *Meretrix Uvasana*, Conrad ; *Meret Hornii*, Gabb ; *Dosinia elevata*, Gabb ; *Tapes Conradiana*, Gabb ; *Cardium Cooperii*, Gabb ; *Card. Brewerii ; Linia multiradiata*, Gabb, &c. This fauna does not contain a single one of the cretaceous genera of Central Europe, while it abounds in European and South American Tertiary genera. There is an almost entire absence of polyparia or corals, and of echinoderms or radiata. This absence of corals is particularly remarkable, in view of the fact that it extends throughout the whole formation of Tertiary rocks of California, in which only two or three specimens of zoöphytes have as yet been discovered, and they were found in the vicinity of Mount Diablo ; not a single one has been found in Southern California.

Tertiary rocks of California.—The middle and lower portions of the Eocene Tertiary rocks are well represented in California by the lignitic strata of Mount Diablo, which are found immediately beneath the strata of Fort Tejon, after which some beds are found, which bear the name of the Martinez and Chico groups, which succeed each other without discordance of stratification, and the fauna of which (chiefly Tertiary) contains some cephalopods badly developed, small, and stunted, as are often the last representatives of a great family or genus which is on the point of becoming extinct. Dr. John B. Trask, who, with the late Dr. Randall, the discoverer of the fossils at Chico Creek, first called attention to these beds at Chico Creek containing cephalopods, correctly referred them to the Eocene Tertiary formation, notwithstanding the presence of the few cephalopods, which he called *Ammonites Chicoensis* and *Baculites Chicoensis*. (See Description of New Species of Ammonite and Baculite from the Tertiary Rocks of Chico Creek, in Proceedings of the California Academy of Natural Sciences, vol. L., p. 85, San Francisco, 1854–'58.) There is absolutely no law in geological science which makes it necessary for cephalopods of the genera known as *Ammonites*, *Baculites*, *Hamites*, *Heliocera*, *Turrilites*, *Ancyloccra*, &c. to disappear entirely from the surface of the terrestrial globe with the rocks of the Secondary epochs. In Central Europe these cephalopods have hitherto disappeared with the cretaceous rocks ; that, however, is but an empirical law, a negative fact, applicable only to Central Europe, and to extend this fact to the whole earth as a well-established law would be contrary to all that we know of the laws of the geographical distribution of animals.

The general zoölogical, lithological, and stratigraphical characteristics of the California rocks which extend from Chico Creek and San Francisco to San Diego and San Bernardino are such as to render the whole analogous to the great Tertiary rocks of the Americo-European basin of the Atlantic, of which it is the representative and the equivalent in the great basin of the Pacific ; only some *Ammonities*, *Baculites*, *Heliocera*, &c., continued to live in the Tertiary seas of the Pacific regions when these genera no longer existed in the Atlantic hemisphere, a fact which is observed in all the geological periods through which the terrestrial globe has passed until the present time. This is not an exception ; it is, on the contrary, a law of the geographical distribution of beings. Real cretaceous rocks are only found, in California, in the northeastern portion of the State, around Mount Shasta. But all the southern and central parts, the real coast range, from San Luis Obispo to Cape Mendocino, the city and peninsula of San Francisco, Mount Diablo, and Fort Tejon, are formed exclusively of stratified rocks of the Tertiary period.

Glacial rocks of Southern California and Pike's Peak.—It cannot be doubted that the Sierra Madre, from Mount San Bernardino to Tejon Pass and Tehachipi Pass, was covered with glaciers during the Quaternary period. The long cañons of San Gabriel, of the Little and Big Tujunga, of Soledad and San Francisquito, served as receptacles or beds (*lits*) for the glaciers which descended from the many high peaks of this chain of mountains, still so little known geographically. In the San Gabriel Cañon we see in several places before reaching Dr. Winson's silver-mines traces of ancient lateral "moraines" on each side of the cañon, and toward the entrance of the cañon, a mile from Buell's Hole, heavy blocks of granite or true bowlders are seen, arranged in the form of a crescent, as if for a frontal "moraine." My exploration of this cañon was too superficial to enable me to speak with confidence of the existence of an ancient glacier ; it seemed to me, however, that there were some traces of a large glacier which descended from the peak of San Antonio.

The traces of glaciers are more visible and striking in the San Francisquito Pass, especially near Jesus Gallejo's ranch, where diorites appear in great masses, and not long after reaching a large lateral valley on the right, as one ascends the pass, we see a very heavy Quaternary drift, with erratic blocks and indications of glacial striæ, on the dioritic and Miocene sandstone rocks which form the bottom of the valley.

I however met with really unmistakable "moraines" only at a single point of my explorations in Southern California, and that was on the road which runs along the

foot of the mountains between Tejon Pass and Caliente. There, just as one goes up from the great plain of Lake Tulare to the plateau which overlooks Caliente, one sees enormous blocks of granite with an entirely northern exposure, piled the one upon the other, with glacial drift mixed among them, which forms, without the slightest doubt, a beautiful frontal "moraine." The road which leads from Bakersfield up to Cerro Gordo, Panamint, and the California Desert passes close by these remains of "moraines."

Although outside of my exploration, I cannot forego the pleasure of referring to the magnificent frontal "moraine" of the great glacier which must have come down from Pike's Peak, have covered the entire valley of the Manitou Springs, and have come to a stand-still midway between Manitou and Colorado City. The house or inn, called the "Half-way House," on the road is built on this frontal "moraine" itself, and the road crosses it at this place. Lateral "moraines," moreover, are seen on each side, especially in the direction of the Garden of the Gods.

Mountain chains and their ages.—Our knowledge of the mountains of California to the south of San Francisco is so limited and such strange confusion has arisen that, notwithstanding the small number of my observations, and the meagerness of the results obtained, I do not hesitate to present them, in the hope that they may lead to a more rational and systematic study of this subject. In general, everything in California that is not in the Sierra Nevada, properly so called, is thrown into the coast range. This coast range is naturally known by various local names. Great confusion has evidently arisen from the placing together of chains of mountains running in totally different directions. of different relative ages and different geological constitutions.

The Sierra Madre.—The Sierra Madre is but an uninterrupted continuation of the Sierra Nevada, which deviates abruptly from its general direction, that is to say, from north to south, with slight tendencies toward the west and east, to form an elbow at Walker's Pass; this elbow runs through the Tehachipi Pass, the Tejon Pass, and stops at the Cañada de las Uvas, in order to resume its principal direction from north to south. This double elbow may be compared to the point of junction of a bayonet on a gun. Geologists have long been familiar with breaks of this kind in the rocks of the earth's crust, and faults of this shape are often met with, which are very appropriately called "bayonet-shaped faults."

What is the extent of the Sierra Madre, which, like the Sierra Nevada, is formed of several parallel ranges, (*chaînons?*) I cannot tell. I may say, however, of my own knowledge, that the Cajon Pass crosses it, and Mount San Bernardino forms a part of it. In 1854, in my exploration on the thirty-fifth parallel, in company with my lamented friend, the late Gen. A. W. Whipple, Engineer Corps, I was struck with the identity of the crystalline rocks of the Cajon Pass with those which I saw in the vicinity of Nevada City and Grass Valley, in the Sierra Nevada, and I did not hesitate at that time to regard them as being of the same geological age, and as containing, in all probability, the same valuable minerals. (See Pacific Railroad Explorations, vol. 3, 4to, Geological Reports, page 171, Washington, 1856.) Since then, my explorations of the San Gabriel, Pacoima, and San Francisquito Cañons have confirmed me in this opinion; Winston's silver-mine, moreover, in the San Gabriel Cañon, reminds one in every respect of the silver-deposits of Virginia City and Washoe. After crossing an enormous granitic mass, on a width of at least 4 miles between the entrance of the San Gabriel Cañon and the Winston mine, one meets with serpentinous dioritic rocks, very hard, and which, near their points of contact with the granite, contain silver and copper in abundance.

Throughout the length of the Sierra Madre one meets with more or less auriferous drift, identical in all its characteristics with that of the placers of the Sierra Nevada; the want of water alone has prevented its being washed to advantage.

The Sierra Madre being only a bayonet-like prolongation of the Sierra Nevada, is of course of the same geological age. This age has hitherto been a problematical one, notwithstanding that it has been proclaimed with some ostentation to be of the Jurassic epoch. There is no doubt that the Sierra Nevada and all the ranges or sierras of Colonel Frémont's "great basin" are much more ancient than Jura.

Like all complicated chains of mountains which extend over large surfaces, the Sierra Nevada was not made at once, but at various times and at different geological dates. The Sierra Nevada and the Sierra Madre have been *terra firma* from the most ancient paleozoic times; and it is certain that the existence of gold dates from those remote periods, like the gold of Australia, the Ural, Wales,Canada, the Carolinas, and British Columbia. Elevations and ruptures of crystalline and stratified rocks took place in the Sierra Nevada, the Sierra Madre, and others of the great basin, toward the close of the Carboniferous, Triassic, Jurassic, and Cretaceous eras, and left very perceptible traces in certain places, especially near Mount Shasta, Bass's ranch, Plumas County; El Dorado Cañon, Humboldt ranges, Mariposa County; Inyo range, Cerro Gordo, and Panamint.

The Tertiary sea washed the western sides of the Sierra Nevada and Sierra Madre, and in some places even penetrated these mountains especially at the bayonet-like

elbow which unites them. Nevertheless the dislocations which broke the Tertiary strata, and raised them to form the Coast Range, the Mount Diablo range, the sierras of San Rafael, of San Fernando, &c., did not appreciably affect the Sierra Madre and still less the Sierra Nevada.

Meeting with a powerful barrier, the Tertiary strata were pressed back against the obstacle of the Sierra Madre and were in some places folded back (*repliées*) upon themselves, becoming contorted, and their beds being turned in an opposite direction, perpendicular to that of these granitic and crystalline mountain-chains. I have not seen any indications which prove that the Sierra Madre was ever subjected to the uplifts of the Tertiary epochs. But, then, at the close of the Quaternary epoch, and perhaps even in the Modern epoch, there are proofs of uplifts and dislocations, which are particularly perceptible on the eastern side of the chains of the Sierra Madre throughout the whole length of the California Desert. The principal proofs of great movements on the sides of the Sierra Madre toward the end of the Post Pliocene age, and during the Modern epoch, are: First, the eastern counterfort of the Sierra Madre at the Cajon Pass, at the very place where the pass attains its greatest elevation above the level of the sea, which, according to Gen. A. W. Whipple, is 4,559 feet; here there are very heavy strata of white sand with rolled pebbles, arranged in beds or scattered through the sand; these strata have been greatly uplifted by the Sierra Madre. Although the stratification of this kind of drift is quite indistinct and confused, it is clearly seen that the whole of this formation dips in an easterly direction at an angle which even attains 45°, which is a very great inclination for rocks which are almost friable, (*meubles.*) The Sierra Madre evidently forms the anticlinal or uplifting mass. The thickness of this formation may be estimated at 1,500 or 2,000 feet. What is its age? It is scarcely possible to tell, because no fossils have as yet been found in it. Nevertheless many of the rolled pebbles contained in this sandy mass are fragments of trachytes and basalts, which shows that this formation is very recent, certainly much more recent than the Pliocene in the vicinity of Los Angeles, and that it can only be referred to the Post Pliocene or Quaternary formation.

On the other hand, the great California Desert, between the Sierra Madre, the Sierra Nevada, Death Valley, and the valley of the Mohave River, indicates the existence of an ancient lake, now dry, the banks and old beaches of which are still seen in many places, notwithstanding the continual movement of the sand, which is violently driven by the west wind. As extinct volcanoes are met with all along the Colorado River, in the basins of the Mohave and the Amargosa, and as very violent earthquakes still take place throughout a great portion of this region, it is natural to suppose that the last uplift and elevation of the Sierra Madre, and of a portion of the Sierra Nevada, took place at the close of the Quaternary period, or even in modern times.

This is the conclusion which I reached in 1854, and which I stated in my "Sketch of a geological classification of the mountains of a part of North America," (see *Geology of North America*, Sierra Nevada system, page 79; Zurich, 4to, 1858,) only I expressed no opinion with regard to the dislocations which had previously taken place in this system of the Great American Desert, which I called a *second meridian system* in North America. The discoveries made since, principally by miners, in the Sierra Nevada and the ranges of the Great Basin, of the primordial or Taconic fauna, and of the Carboniferous, Triassic, and Jurassic faunas, show that from the earliest times of the Upper Taconic, there have been *terræ firmæ* in that region which had emerged from the sea; that the granitic *arêtes* of the ranges which cross this entire country date from the beginning of the Paleozoic ages; that the Carboniferous, the Trias, and the Jura penetrate only into narrow valleys of this system; and that during the Tertiary ages there was an enormous mass of *terra firma* here, which, like the Alps, furnished the arenaceous and pebbly materials for the deposits of the marine and of fresh-water Tertiary rocks, which are now found in California, Utah, Wyoming, and Colorado.

"*En résumé*," the Sierra Madre is altogether the most ancient and the most modern mountain chain of this region of Southern California; that is to say, that the granite, pegmatite, gneiss, dioritic, and metamorphic rocks which form its principal mass date from times anterior to the Paleozoic epochs, *ou tout au plus paléozoïques mêmes;* and that the counterforts of sand, sandstone, and conglomerate, which form the summit of Cajon Pass and of other portions of the eastern region of this chain, date from the Post Pliocene or Quaternary epoch.

COAST RANGE.—The name of *Coast Range* signifies a chain of mountains which follows the line of the coast of the Pacific Ocean. By way of extension, all mountains which are near the coast have been comprised in California under this elastic designation, no regard being had to the direction in which the chains run, whether parallel to the coast or perpendicular to it. After leaving Point Conception and Santa Barbara, and even the Sierra de San Rafael, we find that the mountain chains, instead of running from north-northwest to south-southeast, run from west to east, being perpendicular both to the Sierra Madre and to the sea-coast; so that, properly speaking, the Coast Range, which is so well defined at Monterey and San Francisco, terminates in the southern part of San Luis Obispo County, as was correctly observed by Dr. Trask in

the first geological survey of the State of California. (See *Report on the Geology of the Coast Mountains*, &c., p. 10; 1855; 8vo: Sacramento.) It may be said in general that the Coast Range divides the Pacific Ocean from the valley of the San Joaquin River and of the Tulares beyond San Emidio, not far from Fort Tejon, and that it comprises all the parallel chains which reach the great bay of San Francisco. These mountains continue beyond the bays of Suisun, San Pablo, and the Golden Gates, in a northwesterly direction. What is the principal age of this system of mountains? In a word, at what geological epoch did it make its appearance? I now think, as I did in 1854, when I saw it for the first time with my friend Whipple, that it should be referred to the end of the Eocene Tertiary deposits.

Sierras of San Fernando and Santa Monica.—These mountains, which, with the Sierra Madre on the east and the Santa Susana range on the west, inclose the charming valley or plain of the ancient mission of San Fernando Rey de España, run from west to east. The strata are much broken, uplifted, and inclined, and they are all Miocene Tertiary or molassic rocks, which fixes the age of the appearance and formation of these mountains at the end of the Miocene epoch.

The Santa Susana range, between the Triunfo and Simi Valleys, is but a counterfort of and an appendage to the Sierra de Santa Monica.

The Sierra of San Rafael, which runs right up to the Sierra Madre, at the foot of Mount Pinos, the highest peak of this region, with the peak of San Antonio, seems to belong to this west-easterly system of the San Fernando and Santa Monica Sierras. The same is the case with the Sierra de Santa Ines, back of Santa Barbara. The Santa Clara Valley, with its prolongation almost to Soledad, forms a part of this system, as do the San Francisquito and Castac Valleys.

In consequence of their directions being from west to east, this system of mountains enters the Pacific Ocean on one side and the Sierra Madre on the other, and intersects and completely isolates Southern California from the central and northern portions of the State. The separation is even so great that the railway from San Francisco to Los Angeles is obliged to cross the Sierra Madre twice, viz, at Tehachipi Pass and at Soledad, through several long and costly tunnels, for the sole purpose of avoiding the barrier placed in its way by the Sierra San Rafael; and having reached the Santa Clara Valley, the railroad is still obliged to cross the San Fernando Sierra through a very long and deep tunnel, issuing at last into the San Fernando plains, whence it reaches Los Angeles by following the valley of erosion, which fortunately crosses the Santa Monica sierra, intersecting it perpendicularly almost to its eastern extremity. In reality, Southern California is more disconnected and isolated from California proper than is the latter from the States of Nevada and Oregon.

Hills of Los Angeles.—The hills which surround the city of Los Angeles and separate it from the valley of Bayona or Ballona, from Monte and from Anaheim, are of the Pliocene Tertiary epoch. It is possible, and in my opinion highly probable, that their age is identical with that of the mountains of Cajon Pass, and that they represent on the west side of the Sierra Madre the uplifts and elevations on the east side of that chain to which I have already referred. The sands and conglomerates of the summit of Cajon Pass must, then, be of the same age as the molassic rocks and sandy clays of the old Presidio de Los Angeles. In that case, the deposits of Cajon Pass, instead of being of the Post Pliocene, must be of the Pliocene epoch.

At all events, these two elevations and dislocations of the hills of Los Angeles and of the summit of Cajon Pass, if they did not take place simultaneously, did so at periods by no means remote from each other.

As to the various mountain-chains to the south of Los Angeles, as far as San Diego, and even farther, I can say nothing as to their relative ages, not having visited them. To sum up, we have the following systems of mountains for a portion of Southern California:

I. Sierra Madre, of the Primordial epoch, or Laconic, anterior to the Silurian.

II. Coast Range, of the close of the Eocene epoch.

III. Sierras of San Fernando and Santa Monica, of the close of the Miocene epoch.

IV. Hills of Los Angeles, of the close of the Pliocene epoch.

V. Mountains of Cajon Pass, (east side of the Sierra Madre,) of the close of the Post Pliocene or Quaternary epoch, or, perhaps, even of modern times.

JULES MARCOU.

CAMBRIDGE, MASS., *December* 30, 1875.

Appendix H 2.

REPORT ON THE GEOLOGICAL AND MINERALOGICAL CHARACTER OF SOUTHEASTERN CALIFORNIA AND ADJACENT REGIONS.

United States Engineer Office,
Geographical Surveys west of the 100th Meridian,
Washington, May 13, 1876.

Dear Sir: I have the honor to submit herewith a report upon the geological and mineralogical conditions of Southeastern California and adjacent regions. The country traversed by the party in command of Lieut. Eric Bergland, Corps of Engineers, our able and beloved leader, along the Mohave River, across the Opal, Payute, and Dead Mountains, to Cottonwood Island, in Southern Nevada, thence to the mouth of the Virgin River, across the Colorado to the Cerbat and Blue Ridge Mountains in Northwestern Arizona, from there to Fort Mohave and along the Colorado River to the Mohave range, Monument, and Riverside Mountains, thence to San Bernardino, via Chuckavalla Peak, Coahuila Valley, and San Gorgonia Pass, was of unusual interest in geological, mineralogical, and chemical respects. Nor of less interest was the trip made, in accordance with your orders, by myself alone (after the return of the expedition to Los Angeles) to Panamint, Darwin, Owens Lake, Cerro Gordo, Benton, Aurora, and Virginia City, Nev. An immense area was thus visited from June to November, and valuable collections made.

The chemical analyses of rocks, soils, and mineral springs necessary in connection with my reports were made in the laboratory of the Smithsonian Institution; and I cannot but express my deepest thanks to the Secretary, Professor Henry, for the liberal spirit he has shown in giving me the free use of the laboratory and all necessary utensils and chemicals whenever I desired.

Very respectfully, your obedient servant,

Oscar Loew.

Lieut. Geo. M. Wheeler,
Corps of Engineers, in charge.

CONTENTS.

Taking a bird's-eye view of the great area between the Lower Colorado and the gigantic mountain-chains traversing California from north to south, (the Sierra Nevada and its southern prolongations, the San Bernardino and Jacinto Mountains,) one cannot fail to recognize at once a considerable predominance of three formations, viz: the Primitive, the Eruptive, and the Quaternary. A subordinate position is occupied by the Palæozoic, the Mesozoic, and Tertiary.

While the numerous ranges of hills and mountains mainly consist of granite or trachytic rocks, the intervening valleys are filled by Quaternary deposits. The topographical features of the Mohave Desert differ, therefore, vastly from those of the Painted Desert in Northeastern Arizona, a realm of sandstone, with the characteristic mesa-type of the table-lands.

THE PRIMITIVE FORMATION.

Nearly all the prominent ranges of Southern California belong to this formation, although in a number of instances the axial rock is concealed, as at the Opal Mountains, by Palæzoic strata, at the Blue Ridge Mountains by volcanic flows.

The San Jacinto Mountains, the most southern range of California, consist chiefly of granite, well exhibited in the precipitous faces turned toward the east. It is of dense structure, hard, and a splendid building stone, resembling closely the New England granite. Of mica, it is the black variety (biotite) that dominates in the rock, and among the accessory constituents titanite, turmaline, and garnet deserve especial notice. The titanite* is disseminated in small yellowish crystals through the rock for over 30 miles, (Whitewater to Los Toros,) while the latter two minerals are confined to narrower limits, (near Whitewater.)

* Titanite is also found in the granite of the Sierra Nevada, especially on the Mokelumne and American Rivers, according to Prof. W. P. Blake.

In the San Bernardino Mountains the main mass is granite, accompanied by syenite, gneiss, mica-schist, talcose-schist, and primitive clay-slate. Occasionally, as for instance between Martin's ranch and Cajon Pass, the granite gave rise to the formation of beds of arcose, a rock in which granite *debris* has been recemented, forming a sort of granitic sandstone resembling to some extent granite; but the uniform grain, friability, and rusty surface of the fragments elucidate its true nature.

The western slopes of the San Bernardino Mountains are covered by extensive beds of detritus and *débris*, which in some portions are auriferous, as in Lyttle Creek Cañon, where gold-washing is carried on on a large scale. In the vicinity of the Cajon Pass the Azoic rocks are covered by broken strata of a conglomerate exhibiting a changing dip, being at first about 30° to the south, and finally, near the Pass, 20° to the north. These inclined strata are overlaid by horizontal beds of bowlder and *débris* drift 4 to 5 feet in thickness. While dikes of dyorite and trachyte occasionally appear in the northern portion of the mountain-range, the spurs south of the Gray and San Bernardino Peaks consist largely of volcanic materials.

One of the isolated peaks east of the Jacinto and southeast of the San Bernardino Mountains is Chukawalla Peak, with about 4,700 feet altitude, towering conspicuously above the plain, and whose shape resembles a trapezoid surmounted by a pyramid. The primitive rocks of this mountain are traversed by volcanic dikes, (chiefly trachyte and basalt,) while at the base beds of bowlder and conglomerate have accumulated, the latter showing a dip of from 20° to 25° to the south. Among the primitive rocks a mica-schist of porphyritic structure deserves mention; it consists of a fine-grained mixture of quartz and biotite, containing muscovite in plates of one-sixteenth square inch imbedded. There are said to occur also lead and copper ores at Chukawalla Mountain, but they are not worked.

The primitive rocks of the River-Side and Half-Way Mountains consist of granite and gneiss, the latter garnetiferous. While here we find the feldspar of a green color, it is pink with that of the Monument Mountains north of the former ranges.

At the Mohave range, 20 miles farther north, a series of Azoic rocks is met with, viz, a fine-grained granite, containing simultaneously biotite and muscovite, a syenite with veins of a coarse aplite, then hornblende-schist and quartzite. As this range consists largely of volcanic material, it will be again mentioned hereafter.

Among the mineral occurrences in the primitive rocks of the Cerbat range, muscovite in large plates may be mentioned. In this range are found extensive lodes of metalliferous quartz; also the neighboring Black Cañon range, Payute range, Providence Mountains, and Opal range, contain metalliferous lodes in the primitive rocks.

At the Panamint range we find primitive limestone and slate-clay as accompaniments of the granite.

THE PALÆOZOIC FORMATION.

This formation, chiefly represented by limestone and quartzite, becomes conspicuous at the Riverside Mountains, Opal range, the saline flats of the Mohave, and the Inyo range. On the eastern slopes of the Riverside Mountains, on the Lower Colorado, are exposed, for a distance of over 5 miles, layers of a gray siliceous highly-crystalline limestone, that must be referred to this formation; a view first expressed by Dr. Newberry.* The rock-surface is very uneven, full of little cavities, caused by the sand-winds that attacked the calcareous particles of the rock sooner than the siliceous ones and carried them off. In the rock itself paleontological evidence is in vain searched for, but the accompanying quartzite exhibits crinoidal forms.

Farther north, near Fort Mohave, is another Palæozoic region. The post stands upon a terrace 40 feet in height, consisting of rounded, water-worn bowlders washed down from the mountain-ranges on either side. These large traces, testifying of the activity of the river in former ages, when its bed was far above the present level, contain, among bowlders of trachyte, basalt, and granite, such of a peculiar quartzite resembling semi-opal, and with organic forms (chiefly of crinoids) in a state of astonishing perfection. Treatment with hydrochloric acid removes the last traces of adhering carbonate of lime and brings the forms still better to light. Proceeding farther up the river, Palæozoic limestone is again found at Bowlder Cañon. In the Opal Mountains, at the boundary of Nevada and California, this rock plays an important part, occupying portions of the very crest, exhibiting there frequently inclined strata; thus 3 miles southwest of Ivanpah dipping 60° to the west. In this limestone fossil remains are scarce, a single athyris and few crinoidal stems having been the poor result of a long search.

The flanks of the range are covered by a conglomerate consisting of pebbles of carboniferous limestone, granite, and quartzite, through which numerous gullies and arroyos have been washed. It is a striking fact that while the Opal Mountains are covered largely by Palæozoic strata, these were not met in the opposite Payute range, hardly 30 miles east and of about equal height.

Farther north this formation is met with in the Argus and Inyo ranges, where it

* See Lieutenant Ives's reconnaissance upon the navigability of the Colorado River.

acquires an especial interest on account of rich metalliferous lodes being associated with it.

At the saline flats of the Mohave (Soda Lake, Mohave Sink) the Palæozoic limestone is highly crystalline and siliceous, composes hills and mesas 30 to 40 feet in height, and its strata dip at an angle of 30° to the west.

THE MESOZOIC FORMATION.

On the entire trip through Eastern California cretaceous fossils were not seen, but a deep-red sandstone, that probably has to be referred to the Upper Carboniferous or Trias, as it forms close connection with the Palæozoic strata, was encountered in a few places, viz, the Opal Mountains and the northern spurs of the Black Cañon range, north of the deserted Mormon town Callville, in Southern Nevada. This sandstone, accompanied by gypsum, is exposed again opposite the mouth of the Virgin River, and appears to continue beneath the surface of the great detrital valley to the Cerbat range.

THE TERTIARY FORMATION.

This formation probably is wide-spread in the Mohave Desert, but hidden by the extensive Quaternary deposits. In the valley of the Mohave River thick beds of sandstone, clay, and conglomerate are exposed, whose Tertiary age was recognized by Prof. Jules Marcou.* Granite and quartzite contributed the pebbles to these conglomerates, and as the volcanic rocks, notwithstanding their great abundance all along this valley, do not participate, it is evident that their protrusion took place after the deposition of the Tertiary beds, which latter exhibit uplifts and dislocations caused by the volcanic protrusions. These inclined strata are again overlaid by horizontal undisturbed strata, of moderate thickness; as, for instance, 3 miles east of Grape-vine ranch; also a singular bend noticed in the sandstone strata 10 miles east of Camp Cady may be due to volcanic perturbations.

At Cañon Springs, on the eastern slopes of the southernmost spurs of the San Bernardino range, occur strata evidently of equal age with those of the Mohave River valley, and consisting of light-red and gray sandstone, and indurated bluish clay with seams of gypsum. These strata show a highly-inclined dip to the south and southwest, and exhibit singularly twisted and warped folds. In the horizontal strata of conglomerate overlying them pebbles of basalt and trachyte occur, while none are seen in the inclined strata beneath them.

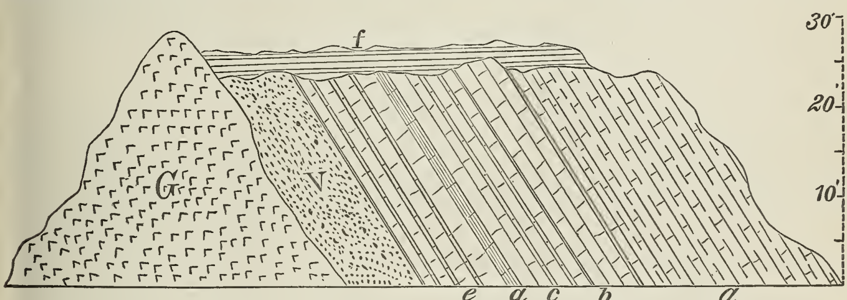


FIG. 1.—Section at Cañon Springs, San Diego County, California.

a. Dark pink-colored sandstone, 80 feet.	Tertiary strata.
b. Yellow sandstone, 24 feet.	
c. Light-pink sandstone, 32 feet.	
d. Yellow sandstone, 2 feet.	
e. Gray sandstone interstratified with clay, 50 feet.	

f. Post-volcanic strata.
g. Granite.
v. Intrusive rock, (trachyte.)

THE QUATERNARY FORMATION.

The Glacial epoch, by which the Quaternary in high and moderate latitudes was introduced, has left but few markings in Southern California. At that time the country was submerged in the Quaternary ocean, and the highest peaks projected as merely small cliffs above the surface. Still the period of cold was not entirely gone when the gradually-rising country acquired considerable dimensions, and the peaks commenced to bear glaciers to a small extent, as the traces of moraines in the San Bernardino and Jacinto Mountains indicate.

* Pacific Railroad Reports, volume 3.

The deposits of the Quaternary are formed by sandstone, conglomerate, clays, and gravel-beds, with occasional saline masses, and fill not only the valleys, but also occur at considerable altitudes in the uplifted mountain-ranges. To the saline efflorescences less attention was hitherto paid than they deserve. Their occurrence appears to indicate that since the recession of the ocean not enough rain has fallen to dissolve them and carry them off. It is true, in several instances, they are of so recent an origin that our conclusions must naturally be much restricted, but, in other cases again, they are of a considerable age. Their origin may be due either to the drying up of salt-lakes left in natural basins after the rising of the country above the sea, or to the desiccation of fresh-water lakes, containing generally, although a very small, amount of mineral salts in solution, or they are the residue of mineral springs.

As the chemical composition of these saline masses may give in many places a clew as to the origin, a number of specimens were analyzed. In the following three cases, the composition is that of table-salt of average quality:

Constituents.*	A.	B.	C.
Sodium chloride	95.51	94.02	95.49
Sodium sulphate	2.44	4.35	2.78
Calcium sulphate	1.01	1.24	0.27
Magnesium chloride	0.60	Trace.	Trace.
	99.56	99.61	98.54

* In every analysis mentioned here, the substance was freed of its moisture in order to facilitate the comparison of the results.

A. Salt of Panamint Valley, deposit 1 to 2 feet deep, covering a number of square miles.

B. Salt covering the plains of Columbus, Nevada.

C. Salt of Death Valley, deposit 1 to 3 inches deep and covering many square miles. Analogous deposits exist in Salinas Valley. (For information and specimens regarding A and C, I am indebted to Lieut. R. Birnie, jr., of your survey.)

Other specimens have a very different composition, as the following table shows; the amount of sulphate of soda is increased and forms in one case (C) the whole soluble portion. Also, carbonate of soda forms a constituent pointing to another source than sea-water.

Constituents.	A.	B.	C.	D.
Insoluble (sand and clay)	42.32	48.68	44.30	51.57
Sodium chloride	38.02	28.08	Trace.	29.00
Sodium sulphate	10.81	8.73	54.08	19.51
Sodium carbonate	7.51	15.06	None.	Trace.
	98.66	100.55	98.38	100.08

A. From the saline flats of the Mohave, thickness 1 to 3 inches; area, about half a square mile.

B. From Point of Rocks, forming isolated saline spots.

C. From shore of Kern Lake. } Collected by D. A. Joy, geologist of party No. 2.
D. From Tehachapi Pass. }

Another deposit of small extent, however, derived from a spring near Stone's Ferry, gave the following result:

Insoluble (clay)	57.40
Sodium sulphate	32.30
Magnesium sulphate	6.32
Calcium sulphate	3.51
	99.53

An alkaline deposit near Benton, (Mono County,) gave the following result:

Insoluble (sand)	3.70
Sodium carbonate	70.31
Sodium sulphate	11.25
Sodium chloride	13.76
	99 02

Saline efflorescences composed of chloride and sulphate of sodium are the commonest; less frequent is the occurrence of sodium carbonate; still rarer are borates. At one place, Coyote Hole, Inyo County, the deposit of borate of soda is of considerable dimensions.

Extensive deposits of nearly pure rock-salt are found in the valley of the Virgin River, about 10 miles above its junction with the Colorado. Geological circumstances point toward their Quaternary age and indicate that Bowlder Cañon is older than these deposits. Before the cutting through of the Black Cañon range, *i. e.*, before the completion of Bowlder Cañon by the Great Colorado, the water must have accumulated in a large lake 40 miles in width, and bounded in the east by the pleateau through which now the Grand Cañon extends. It is upon the bottom of this ancient fresh-water lake that the large rock-salt deposits are found. These conditions render it highly probable that their formation took place after or by the receding of the Quaternary ocean, and that Bowlder Cañon was in existence *before* the submergence of the country at this period, which becomes evident also by the characteristic position of the Quaternary conglomerates within the head of Bowlder Cañon and in the neighboring washes. On the other hand, evidence is furnished, by erosion, that the cañon is not older than the Tertiary epoch, for there are dikes of basalt cut through so perfectly even with the inclosing syenite at quite a considerable distance above the river, that we must conclude the basalt-dikes existed *before* the erosion of the cañon; that is, the age of the cañon has to be referred to the later Tertiary.

The lapse of time required for the completion of the great cañons of the Colorado is, after all, not so great as one would be inclined to estimate at first sight. If we take the erosion of Niagara Cañon, that is, the retrocession of Niagara Falls, as an example, which amounts, according to Hall and Lyell, to 1 foot a year, a period of one and a half million years would be required to complete the Grand Cañon of two hundred and eighty miles in length. Not less than by the saline efflorescences and salt-deposits is attention arrested by the conditions of the Quaternary conglomerate, it being exceedingly coarse and occupying frequently localities far distant from the mountains that contributed the pebbles. This fact can hardly find any other explanation than that powerful currents agitated the waters of the comparatively shallow Quaternary ocean and distributed the coarse material over large areas.

These conglomerates acquire a considerable thickness, as elucidated by the artesian borings of San Bernardino, which penetrate them for 140 feet. Neither limestone nor clay beds are struck by these borings, and the water rushes up as soon as the loose sand beneath the conglomerates is reached.

FRESH-WATER LAKES OF THE QUATERNARY PERIOD.

After the receding of the waves the country enjoyed a climate moister than that of the present day, as is indicated by the formation of a number of fresh-water lakes that left nothing but the barren clay bottom, whose numerous imbedded shells give evidence of a more numerous animated life.

Owens Lake, now charged to such a degree with salts * that molluscous or fish life is impossible, was formerly an extensive fresh-water lake, as the recent shells in its immediate vicinity indicate.

Mono Lake had gigantic dimensions, to judge from the well-defined shore-lines, 15 miles from its present margin.

Soda Lake, now a barren clay flat of forbidding appearance and desolating sight, (the saline flats of the Mohave River,) was a large water basin, but the largest lake of Southern California existed in the Coahuila Valley, and to all appearances up to a period less than a thousand years before the present day.† Among the coarse granite-sand of its former western shores formed by the eastern slopes of the Jacinto Mountains are found millions of minute fresh-water shells, (*Amnicola thryonia*,) most delicate structures, that would long ago have been crushed between the rolling sand and have disappeared, if the period elapsed since the desiccation had been a considerable one. A calcareous crust, several inches in thicknessand of quite fresh appearance, covers the granite of the slopes, and marks exceedingly well, by a far-stretching horizontal line, the shores of the former lake,‡ whose depth was about 125 feet and surface probably over 1,000 square miles. This porous crust, of the structure of a sponge, contains numerous fresh-water shells. The now dry clay bottom is covered with patches of white salt efflorescences, and nothing save an occasional stunted Halostachys inter-

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* Should this be due to the bursting forth of mineral and thermal springs opened by volcanic forces? Lava of recent origin occurs in the vicinity and mineral springs are numerous in the neighboring Coso Range.

† The Kauvuya Indians of that region have still a tradition of the lost lake.

‡ This region has been described before by Prof. W. Blake. See Pacific Railroad Reports, vol. 5.

rupts the evenness of the flat. A specimen of this clayey soil gave, on analysis, the following result:

Clay with fine silt	64.70
Calcium carbonate	3.36
Calcium sulphate	0.43
Sodium chloride	10.52
Sodium sulphate	3.90
Magnesium sulphate	Trace.
Calcium phosphate	Trace.
Potassa, lithia	Traces.
Chemically-bound water	15.68
	98.59

This soil is unfit for agriculture, containing too much clay and salts.

If, on the one hand, desiccation of former lakes proves that the amount of evaporation exceeded that of the aqueous precipitates, there exist, on the other hand, facts tending to prove that the dryness of the climate *is still on the increase*, namely, the disappearance of forests within the last three centuries and the drying up of springs within the last fifty years.*

These phenomena recall our observations in New Mexico and Arizona, where indications of increasing dryness are numerous; to mention only the forests of dead cedar-trees standing mummy-like, the occurrence of shells of land-snails (*Planorbis*) in localities where not a single snail is found at the present day, the deserted ant-hills, the dry arroyos, and the ruined towns of now barren tracts.†

In close connection with the decrease of aqueous precipitates in New Mexico, Arizona, and Eastern California, appears to stand the *increase* in Utah, the Great Salt Lake having risen 15 feet in the last twenty-five years, and will, if this accumulation continues, submerge the capital of the Latter Day Saints at no very remote period.

The most satisfactory explanation of these phenomena appears to me can be given by the assumption of changes in the country-level. A gradually rising country will experience a *decrease* in the annual mean of temperature, consequently, also, in the amount of evaporation; while, on the other hand, the aqueous precipitates will *increase*, the distance of the clouds becoming smaller. As the attraction grows with the square of proximity, a lifting of 100 feet of an extensive mountainous country will suffice to change the climate perceptibly. Two causes, therefore, co-operate to increase number and volume of springs and to swell creeks and lakes. My hypothesis is this, that New Mexico, Arizona, and Eastern California are undergoing a gradual subsidence, while Utah is, like the coast of California, slowly upheaved.

A characteristic feature of the Mohave Desert is the black coating of rocks and of the bowlders and gravel‡ that cover the barren plains, adding perceptibly to the dismal impression of the scene, the blackening appearing like a mourning garb for departed flora. Miners call these rocks "sunburnt," and as curious as this expression sounds to the ear of the naturalist, there is a grain of truth in it, the black coloration being of the deepest shade where the surface of the bowlder is exposed to the direct sunlight, while at the under side it is much less developed and sometimes replaced by a reddish color.

Analogous phenomena were observed by Littel in the Libyan Desert, by others at Syene, at the Congo River, and by Humboldt on the Orinoco. Berzelius, who examined the coating from the latter locality, upon the request of Humboldt, declared it due to mixture of oxide of iron and manganese. A chemist can hardly be long in doubt in regard to it, as hydrochloric acid dissolves the coating with liberation of chlorine, and manganese easily can be shown in the solution thus obtained. It appeared to me a matter of some interest to ascertain the quantities necessary for the production of the black coating, and for this purpose a blackened small bowlder, weighing 80 grams, was treated with hydrochloric acid until the natural color of the rock (granite) developed. The acid poured off gave:

Sesquioxide of iron	0.078 gram.
Binoxide of manganese	0.038 gram.
Oxide of nickel	traces.

* The miners of El Dorado Cañon, in the Black Cañon range, stated to me the ceasing of a large spring in the vicinity within the past fifteen years.

† See annual report U. S. Geographical Surveys West of the One Hundredth Meridian. 1875.

‡ On the eastern slopes of the Payute range, some 20 miles east of Cottonwood Island, a bed of coarse conglomerate, 10 feet in thickness, was observed, of which each pebble was provided with the black coating.

The questions arise:

1st. Whence was the manganese derived?

2d. How was the coating produced?

Chemistry points to the widely-spread *pink* and amethyst colored granites, gneisses, limestones, and sandstones, and leads to the conclusion that the manganese present in the state of proto and sesqui oxide in these rocks furnished also the binoxide for the black coating of the Quaternary drift, by becoming dissolved as carbonate of manganese upon the disintegration of the rocks, covered partly with the water of the slowly-receding, shallow ocean, and by being deposited afterward upon the rocks of the ground, where it changed gradually from the state of proto and sesqui oxide to the binoxide by the influence of air and sunlight.* This fact forms an analagon to the production of coatings of oxide of iron by waters that contain ferrous carbonate; and can be observed on a grand scale at localities where earthy carbonate of manganese is found. B. von Cotta mentions one instance of this kind in his "Treatise on ore deposits" occurring in the gold-bearing regions of the Rhine: "Widely-extended strata of those slates consist largely of white or reddish rhodonite, (carbonate of manganese,) which, when exposed to the air, turns *as black as coal, since it becomes incrusted by a very thin layer of manganite.*"

There can hardly exist a doubt that the pink color of the lime and sand stones of the Mohave Desert also is due to the manganese derived from the granites,† while, on the other hand, the volcanic rocks may have contributed their share in coloring the Quaternary drift.

At Mountain Springs, in the Cerbat range, a pink chalcedony was observed that most probably has derived its manganese from the trachydolerite of the vicinity.

That the pink color of the palæozoic limestone of those regions is due to manganese, was easily proven by dissolving a piece in hydrochloric acid, adding excess of ammonia, filtering off the hydrated oxide of iron, precipitating the filtrate by sulphide of ammonium, and fusing the precipitate with soda and a little saltpeter.

THE ERUPTIVE FORMATION.

The eruptive activity, once so extensive in the countries west of the Rocky Mountains, appears to have reached its summit in California, or, more generally mentioned, in the countries of the Pacific coast. Here appear to exist unusually favorite regions of the operations of the Plutonic powers; for the most ancient as well as the most modern geological records tell of convulsions and outbursts of molten masses, and even at the present day Pluto manifests his subterranean energy by frequent shocks and earthquakes.

There is no mountain-range of Southern California free from eruptive material, which either occurs in injections and dikes, or forms entire hill-ranges and mountains, nor are there any known rocks that do not find a representative here. From the oldest erupted gneiss, syenite, diorite, up to the porphyries, trachytes, and basalts, the series is complete. In coloration, in structural character, no greater variation could be found, and in the bursting, uplifting, and dislocating of sedimentary rocks, a geological genius could not be more productive in furnishing designs.

Eruptive gneiss.—Near the northern end of Coahuila Valley, rise abruptly above the sandy plain two hills 20 to 30 feet in height, of highly crystalline limestone, of either primitive or palæozoic age, whose strata dip at an angle of 36° to 40° to the eastward, traversed by a dike of a highly micaceous gneiss 1 to 2 feet in thickness.

The rocks are at the contact-surfaces very friable and metamorphosed. The intrusive gneiss shows by the position of its mica-plates a stratification parallel to the limestone layers, indicating the effect of pressure during the consolidation of the injected rock mass.

Eruptive syenite.—A great portion of the eastern slopes of the Buena Vista Mountains, the portion of the Inyo range in which the mining-town Cerro Gordo is situated, is composed of syenite, to whose eruption is not only due the remarkable displacement of strata of palæozoic limestone on the eastern slopes, (see Fig. 2,) but also the disturbances produced on the west side of the mountains, the strata of slate, sandstone, and limestone standing on end for a distance of several miles.

Section for the eastern slopes of Buena Vista Mountain 3 miles east of the mining-town of Cerro Gordo. Strata of palæozoic limestone, P, standing upon their vertex, and forming with each other an angle of about 80°. E, eruptive syenite, entering the strata like a wedge.

* Mr. Joy, geological assistant of Division No. 2, mentions in his notes a hot spring near Montan's ranch, California, whose waters deposit a black coating over rocks, probably due to the formation of binoxide of manganese from the protocarbonate held in solution by the spring-water.

† Pink granites were observed at the Riverside Mountains, Monument Mountains, Chukawalla Peak, Mohave River Valley, Payute range, and other localities.

Eruptive granite.—At the Saline Flats of the Mohave River, at Dead Mountain, and in the Opal ranges, granite appears under circumstances indicating the eruptive character of the rock.

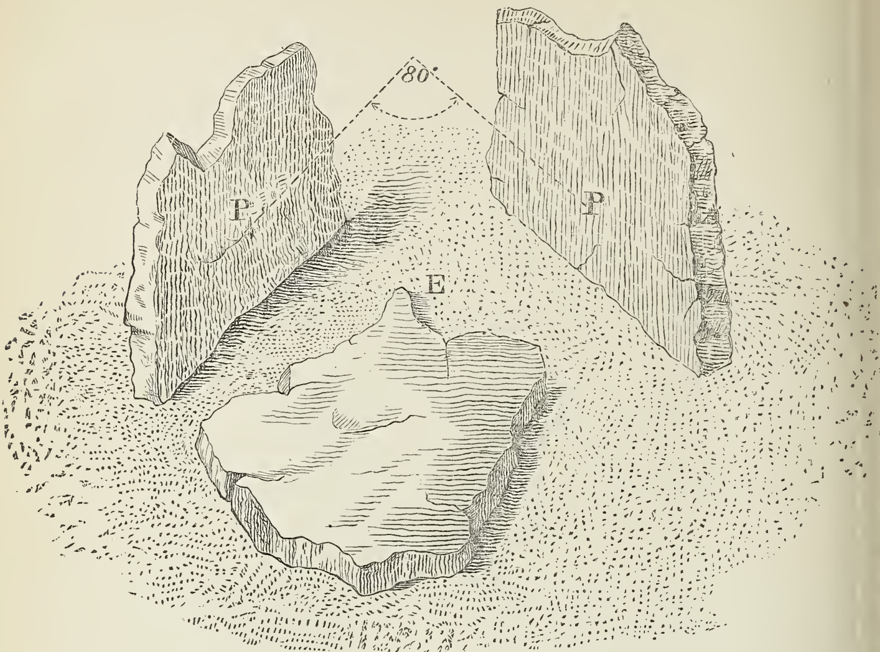

FIG. 2.—From Buena Vista Mountain.

Eruptive diorite.—Two narrow dioritic dikes, 2 to 3 feet thick and but about 15 distant from each other, traverse the calcareous sandstone of palæozoic age near Duckweiler Station, at Owens Lake, in such a manner that the phenomenon strikes even those who never were devoted to observations in nature most impressively, (see Fig. 3.) At the contact-surface of the eruptive and the sedimentary rock, the latter is fritted and very hard, (so-called porcelain jasper,) due to the metamorphosis produced by the heat of the erupted rock.

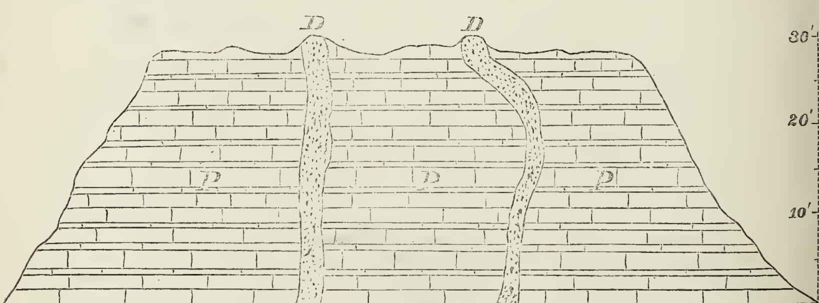

FIG. 3.—Section in vicinity of Owen's Lake.

P, sandstone wall, 30 feet high; strata dipping at an angle of 24° toward the east; D, dikes of diorite.

In the vicinity of the mining-town Ivanpah, in the Opal Mountains, and farther east, at Mount Newberry, on the Colorado River, dikes of diorite in granite are very extensive, and the rock assumes in part a porphyritic structure.

At Chuckavalla Peak, in San Diego County, occurs an eruptive rock of the appear-

ance of diorite, but has to be probably referred to the propylite of Richthofen, although it is difficult to draw a line of distinction between these two rocks, propylite being in many cases nothing but Tertiary diorite.

Andesite.—A rock with a black vesicular matrix, containing imbedded well-formed crystals of orthoclase and hornblende, composes several peaks of the Payute range about 28 miles east of the Colorado River, at Cottonwood Island. I have no doubt that it corresponds to Richthofen's andesite, a volcanic rock so prominent in the South American Andes; whence its name.

* *Trachyte.*—This is by far the most extensive of all erupted materials in California, and the varieties which it exhibits are numerous. Basalt, covering immense tracts in Arizona and New Mexico, dwindles here into insignificance. The following list gives an approximate idea of the varieties met in various places of Southeastern California and adjacent regions:

Locality.	Matrix.	Imbedded minerals.
Mohave Range	Pink	Sanidine, biotite.
	Brown, vesicular	Sanidine, (sparingly.)
	Gray-brown	Oligoclase and zeolite.
	Brownish-lilac	Sanidine and hornblende.
	Gray	Hornblende, (sparingly.)
	Reddish-pink	Quartz, muscovite, orthoclase, and sparingly hornblende.
Riverside Mountains	Red	Orthoclase.
	Lilac	Oligoclase and biotite.
Cottonwood Island, (Colorado River.)	Gray, vitreous	Many large orthoclase crystals, with little biotite.
	Brown	Red orthoclase and white sanidine.
	Pink brown	Biotite and sanidine.
Dead Mountain, on the Colorado River.	Gray pink	Oligoclase and hornblende.
	Brown, vesicular	Zeolite, with (sparingly) hornblende.
	Light gray	Large orthoclase crystals, sparingly hornblende.
	Gray, amygdaloid	None.
Black Cañon range, (north of the former.)	Brown, amygdaloid	Sanidine and hornblende. Zeolites in the amygdaloid spaces.
	Green, vitreous	Oligoclase and biotite.
Payute range	Reddish	Orthoclase and biotite.
Callville	Slate color, vesicular	Orthoclase.
Cucamungo Peak	Slate color	Do.
El Dorado Cañon	Pink brown	White orthoclase.
Blue Ridge Mountains, Northwest Arizona.	Gray pink	Densely crowded with small crystals of feldspar, biótite, and hornblende.
	Nearly white, vitreous	Much sanidine and little biotite.
	Light green	Quartz, orthoclase, and biotite.
	Reddish, very siliceous	None.
	Gray pink	Oligoclase and biotite.
Detrital Valley, Northwest Arizona.	Gray, vesicular	Large number of small sanidine crystals.
Caves, Mohave River Valley.	Red, vesicular	Orthoclase.
	Gray	Biotite and sparingly oligoclase.
	Gray, vitreous	Sanidine in large crystals.
	Dark gray	Little oligoclase and hornbiende,
Saline Flats of the Mohave River.	Slate color	Orthoclase.
	Gray, vesicular	Quartz, hornblende, and orthoclase.
Grapevine Ranch, Mohave River Valley.	Reddish	Sparingly sanidine and hornblende.
Camp Cady, Mohave River Valley.	Light gray	Sanidine, (sparingly.)
Chuckawalla Peak	Pink	Hornblende, oligoclase.
Cañon Springs	Red, with black stripes	None.

That these trachytic outbursts did not take place at one and the same time, but were repeated at long intervals, becomes evident after even a cursory examination. Trachytic masses repeatedly forced their way up through the identical fissures, and examples of this kind are well exhibited at the Needles † in the vicinity of the cañon which the Colorado has cut through the Mohave range. Here the strata of volcanic tufa show

*All the different varieties of volcanic rocks mentioned in this report have been collected. Of a large number microscopical sections will be studied by a specialist in this branch.

† These gigantic pinnacles, consisting of trachyte and trachytic breccia, have most probably obtained their singular shape by the erosive action of the river, when it was formerly running at a level of 1,000 feet and higher above the present bed.

manifold dislocations by later outbursts, and one of the instances is represented by the following section:

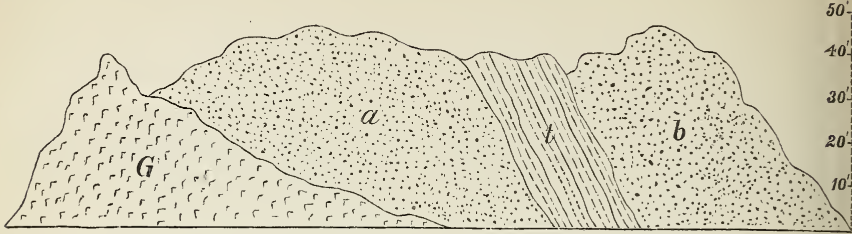

FIG. 4.—Section from the cañon at the Needles.

G. Granite.
a. Trachyte with pink matrix, containing imbedded quartz, orthoclase, and biotite.
b. Trachyte with brown matrix, imbedded sparingly oligoclase and hornblende.
t. Trachytic tufa containing pebbles of a trachyte with a reddish matrix, in which is imbedded sparingly oligoclase.

Here we have evidence of three distinct outbursts of trachytic masses; the trachyte that gave rise to the formation of the tufa, *t*, being the oldest, then following *a*, uplifting and dislocating the tufa strata, and finally the trachyte, *b*, protruded and overflowed the tufa on the opposite side from *a*.

In the Blue Ridge Mountains and Mohave range the trachytic eruptions appear to have reached their maximum, the masses measuring thousands of feet in height. At Union Pass, in the Blue Ridge Mountains, rhyolite, felsite, pitchstone, and globular porphyry, or pyromerid, form the accompaniments of the trachyte, while in the Mohave range basalt is associated with it. The volcanic tufas, conglomerates, and breccias of the latter range contain only material derived from trachyte and none of the neighboring basalt; thus giving evidence of the more recent age of the latter. The primitive rocks of the Mohave range are not so extensively covered by volcanic material as in the Blue Ridge Mountains. However, in the singular outlines of their peaks and crests, assuming fantastic shapes of towers, domes, and castles, the more sharply defined as they are devoid of forests and verdure, both rival each other.

In the Riverside Mountains obsidian accompanies the trachyte; at Chuckawalla Peak, basalt and a phonolite rich in zeolite; in the southern spurs of the San Bernardino Mountains, pumice; and in the Mohave River Valley, rhyolite and recent lavas. In this valley a fine section of volcanic rocks is exposed at the Cañon of the Caves, where, for a stretch of 5 miles, a series of trachytes of most vividly contrasting colors impress the traveler with the grandeur of inorganic nature. The spaces and fissures between the dikes are filled by Quaternary clays and conglomerate.

Trachydolerite.—This rock forms dikes and hills in the Mohave, Payute, and Cerbat ranges, at Mountain Springs. It also is largely spread upon the island of Santa Cruz.

Basalt.—The most notable localities are the Virgin River Valley and vicinity, and Black Mountain range, in Southwestern Nevada; the eastern portion of Detrital Valley, in Northwestern Arizona; the Mohave range, and the Mohave River,* in Eastern California. The displacements due to its protrusion are on a grand scale in the mountains north of Callville, in Southern Nevada, from which region the accompanying section is taken.

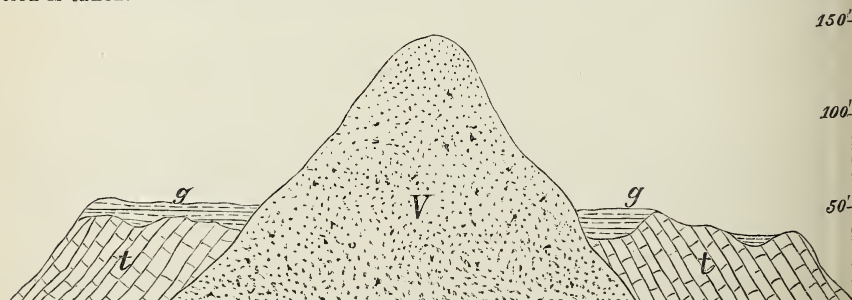

FIG. 5.—Section from vicinity of Callville, Nev.

V, Basaltic protrusion; *t*, Triassic strata; *q*, Quaternary conglomerate.

* The Mohave range has nothing to do with the Mohave River, being situated much farther east, and crossing the valley of the Colorado.

As I have demonstrated the presence of cobalt and nickel in basalts of New Mexico, (see survey reports Vol. III,) I searched for these elements in the California basalts, and was surprised in finding small quantities of them, widely distributed.

At first one might form the conclusion that their presence is due to the olivine, a mineral which contains nickel as a normal constituent, as shown by Stromeyer, but a closer examination will refute this hypothesis, as the basalts of Southern California contain but rarely olivine as an accessory constituent. I am of the opinion that these elements are connected with the magnetic iron of the basalts, and this idea is sustained by the fact that upon digestion of the finely pulverized rock with concentrated hydrochloric acid for from six to twelve hours the whole of the nickel and cobalt is with the iron in the solution, while the labradoritic and pyroxonic particles are but little attacked. If the acid solution thus obtained be freed from most of its acid, then supersaturated with ammonia, filtered, evaporated, ignited, and the residue treated with dilute hydrochloric acid, the presence of cobalt and nickel may be easily demonstrated by the common methods. Among the rocks and tufas tested I found the respectively largest proportion in the *tufas* of the trachydolerites of the island of Santa Cruz.

Lava.—Vesicular lava, of apparently very modern date, was observed at Camp Cady, in the Mohave River Valley, and at the southeastern margin of Owens Lake.

Are we now justified in assuming that with the lava outbursts the plutonic powers left their favorite theater, or have retired to seek another field of activity? The circumstances do not testify to the affirmative of such an assumption, for frequent rumblings indicate the existence of latent volcanic powers. In the vicinity of Owens Lake hardly three weeks pass without a slight shock being felt. The most violent shock remembered by the settlers in the Owens River Valley took place at 3 p. m. of the 26th of March, 1872, reaching from Owens Lake north as far as Aurora, Nev., a distance of about 130 miles. The changes thereby produced at Owens Lake are still visible. I saw the fractures of the earth, now partly filled with sand, the stratum of sandstone raised 14 feet, and a spring produced by newly-formed fissures. Huge masses of rock became detached on the east side of the Buena Vista Mountain and hurried thundering down the slopes. At the village of Lone Pine resulted most terrible effects; the dwellings were thrown down and sixty persons killed in a twinkling of an eye. Similar effects, but on a smaller scale, were experienced at Independence. The vibrations lasted several seconds, and the noise resembled that of a train of heavy wagons hurrying over a stone pavement.

At San Diego and Fort Yuma, in Southern California, the shocks average nine per annum. The most violent in the memory of the whites was that of November 9, 1852, with a great frequency of subsequent shocks, lasting for about two months. Professor Blake reports that a portion of Chimney Peak was thrown down, and cracks and fissures opened in wide circumference of Fort Yuma. Forty miles south from this post a number of mud volcanoes were formed, whose waters had a temperature of 170° F.

The frequency of earthquakes did not fail to be noticed by the early Spanish visitors. Sebastian Viscaino said, (1596:) "No es el mar peligroso es su costa tierra muy templada." (It is not the sea that is dangerous, it is the trembling coast.)

GENERAL GEOLOGICAL HISTORY OF SOUTHERN CALIFORNIA.

This is, in a few words, as follows: The country was partially submerged during the Azoic period, and, probably, with repeated changes of level, partly during the Palæozoic, began to rise and remained above water until toward the close of the Cretaceous, when it sank to a great extent below the ocean and remained there up to the middle Tertiary; began then to rise, and reached finally a level so far above the present one that the islands now separated from the coast by the Santa Barbara Channel formed part of the continent, as is indicated by the elephants' teeth* found on them, and by the occurrence of a small fox derived from the continental fox by gradual transmutations.

Toward the close of the Tertiary the country was the home of the buffalo, horse, rhinoceros, llama, tiger, and mastodon.† That brilliant age experienced, however, a great series of volcanic disturbances that had commenced early in the Tertiary, and continued up to quite modern date, in longer or shorter intervals.

With the decline of the Tertiary, the country sank again until the mountains projected as mere cliffs above the ocean. Mighty currents agitated the waters and assisted in forming the Quaternary conglomerates. The Quaternary period was so far advanced that the glacial epoch had passed its zenith, when the country emerged once more from the watery grave to salute the vivifying sunbeams. The coast is still rising at the present day, at a rate of about 5 feet per century, and, as the Santa Barbara Channel has 60 fathoms depth, the islands off the coast will, in seven thousand two hundred years, be again united with the main land, if the rise thus continues. It is, however,

* See Proceedings of California Academy of Sciences, 1873.

† See article of Professor Leidy in the Proceedings of California Academy, 1873.

probable there will be interruptions, cessations, for a longer or shorter time, as may be inferred from the terraces all along the coast of Southern California, indicating unmistakably the shore-lines of the ocean during the cessations in preceding periods.

ON THE METALLIFEROUS VEINS OF CALIFORNIA AND SEVERAL PECULIAR ORES.

In regard to mineral wealth, California occupies a prominent position, not only with reference to the quantities of the precious metals, but also to those metallic elements that occur but sparingly in other countries. Gold, silver, platinum, mercury, copper, lead, antimony, arsenic, tungsten, tellurium, molybdenum, bismuth, chromium, manganese, iron, nickel, cobalt, zinc, are found in various ores.

A series of the most important ore-veins, among them some discovered quite recently, lie in Inyo and Mono Counties, for description of which the reader is referred to the general report. Attention is only invited here to some peculiarities connected with them; above all, the walls slickensided to such a degree of perfection and to an extent rarely witnessed in other mining regions. The Hemlock lode, in the Panamint Mountains, shows this phenomenon on a grand scale and of extraordinary beauty. Another peculiarity are the so-called "horses," large bowlders of wall-rock that became detached and dropped into the fissure during the process of vein-making. Further mention must be made of the "breaks," large hollow fissures encountered occasionally in the walls. The "horses," as well as the "breaks," are doubtless due to volcanic disturbances; the former to earthquakes *before* the vein was filled, the latter long after the perfection of it.

If we look at the fissure-veins, on one hand, and observe on the other the immense masses of erupted rocks in those mountains, one cannot fail to suspect a connection, and to ascribe, with Baron von Beust, the production of fissures to volcanic forces, or earthquakes that accompanied the eruption of molten rocks.

But how, may we ask, were these cracks filled with vein-matter? Neither the lateral infiltration nor the injection hypothesis are sufficient to account for all peculiarities met here, but if we consider—with Elie de Beaumont—the veins as the product of hot waters which entered charged with mineral salts these immense fissures from beneath and filled them to the brim, we may easily explain the presence of the quartzite, the carbonate of lime, carbonates of lead and copper,* as well as the occasional *banded structure* of the veins, the deposits being made at first upon the walls of the fissures, and gradually filling up to the center. If the character of the mineral water changed after a certain period, a change of the nature of the deposit would of course be the result, and thus the banded structure seen occasionally in veins accounted for.

The deposition of vein-matter from the hot waters is partially due to a loss of temperature of the water, partly to a loss of carbonic acid in contact with the air at the fissure surface. The formation of the metallic sulphurets might be explained by the subsequent entering of waters charged with sulphureted hydrogen, converting the metallic carbonates into the sulphurets.†

No country abounds to such a degree with hot springs as California and Nevada, and here it is especially the vicinity of mining districts where they are encountered. There are thermal springs in Death and Panamint Valleys, adjoining the Panamint Mountains with their veins; there are others in the Coso range, near the mines of Darwin, another near Blind Spring mining district, and again between Carson City and the famous Virginia City mines. In one of the latter, the Imperial Mine, the workingmen struck, a few years ago, hot water emitted with such force that they could not escape a thorough scalding of their feet. Who would deny that the system of thermal springs was formerly much more extensive in California than at present, if one sees the glaring and decisive marks they have left, the cones they had built, the coatings‡ produced? It may be that thermal springs are forming at the present day far beneath the surface mineral veins, and their final filling may be the result of many springs dying out after certain periods, the channels becoming closed up.

It may also be, that if large quantities of water of certain hot springs be analyzed, traces of metals, as lead, copper, or silver, could be discovered. I add here an interesting passage quoted from Cotta's "Ore Deposits," page 531: "It appears from Daubrée's researches, that the mineral water of Plombières still deposits minerals which are characteristic for the variety of lodes mentioned, and it is by no means impossible that there, at a corresponding depth below the surface, such lodes are still forming."

* There is not a single metallic carbonate that would not be a little soluble in water charged with free carbonic acid.

†A singular fact worth recording is that, as a rule, the lead-mines of Mono and Inyo Counties are in limestone, while the copper-ores occur as an impregnation of quartzite ledges in primitive or erupted rocks.

‡A fine specimen of a snow-white coating over paleozoic limestone is seen on the eastern slopes of the Buena Vista Mountains, three miles east of Cerra Gordo.

ANALYSIS OF THE TIN ORE OF TIMESCAL, SAN DIEGO COUNTY, CALIFORNIA.

The tin mine of Timescal became famous by the continuous litigations it caused, not by the metal produced. No work was done for seventeen years, litigation preventing it. I was unable myself to visit the mine, hence can express no opinion as to the prospects, but received specimens of the peculiar ore from two persons, one in San Bernardino, the other in Los Angeles; the specimens resembled each other perfectly, and were said to represent the average ore. It is difficult to recognize in this black rock a tin ore; nobody would suspect the presence of tin; still chemical analysis reveals it, although the quantities, at least in the specimens at my disposition, are small.

Luster, dull; streak, grayish; hardness = 3; specific gravity = 3.40. In the uniform black mass brighter particles of a crystalline structure are recognizable. The ore contains no water of hydration, and is but with great difficulty attacked by acids, whereby some oxide of iron is obtained in solution. Fusing potassa decomposes the ore rapidly, and if the mass be treated with water a yellow powder, containing oxide of iron, silica, potassa, and antimonic oxide, remains insoluble, while tin is found in the alkaline solution. The former is easily decomposed by hydrochloric acid.

The quantitative analysis gave—

Silica	39.70
Oxide of iron*	35.85
Alumina	5.01
Oxide of tin	3.52
Oxide of antimony	3.98
Lime	5.81
Potassa } Soda }	4.32
Titanic acid	traces.
	98.19

ANALYSIS OF PARTZITE, OF BLIND SPRING DISTRICT, CALIFORNIA.

This peculiar silver-ore is thus far known to occur only at one locality, the Blind Spring Mountains, near Benton, in Mono County, California. I visited myself the mine in which it used to be found in abundance, (the Comanche lode;) but at present, with the deepening of the shaft, it becomes very rare, the sulphurets† predominating over the oxidized ores and carbonates. The color of the partzite varies from yellowish-green to black; no crystallization is perceptible; luster, dull; fracture, conchoidal; streak, gray to brown; hardness = 3; specific gravity = 5.324.

Nitric acid dissolves it partially, with disengagement of red fumes, due to the presence of protoxide of iron in the ore becoming peroxodized. The quantitative analysis revealed the presence of copper, lead, iron, silver, and antimony. The latter element is present in the state of antimonic acid, as I have proved by treatment of the finely-pulverized ore with potash and addition of chloride of sodium. The ore has been previously analyzed by A. Arents,‡ who calculates the antimony as the oxide, and finds the specific gravity = 3.8, a number which is utterly impossible in consideration of the composition, as antimonial ores have never less than 5.2 specific gravity. The result below given would correspond approximately to the general formula:

$$S\,bo_5,\ 4\,Ro,\ 4\,Ho,$$

but it is very doubtful whether this ore can be designated as a mineral species, as the necessary requisites are wanting. It is probably a mixture of antimoniate of iron and silver with the hydrated oxides of copper and lead.

The great deviations in the composition of this ore are shown by the following comparison of the analysis made by Mr. A. Arents (2) and myself, (1.)

	(1.)	(2.)
Antimonic acid	34.03	47.65
Oxide of copper	18.39	32.11
Oxide of silver	3.28	6.12
Oxide of lead	23.51	2.01
Protoxide of iron	10.04	2.33
Water	11.30	8.29
	100.55	98.51

* A small portion of the iron is present as magnetic oxide.

† Argentiferous antimonial lead and copper sulphurets.

‡ American Journal of Science and Arts, 1867.

List of minerals and rocks collected and observed by A. B. Conkling, geologist, assistant of Division 3, in Southern Colorado and Northern New Mexico, and by O. Loew, mineralogist and chemist of Division 4, in Southeastern California and adjacent parts of Nevada and Arizona.

COLLECTED BY OSCAR LOEW.

Minerals.	Locality in California, &c.	Locality in Colorado, &c.	Remarks.
1. ELEMENTS.			
Gold, native	Little Creek; Cerro Gordo	Ute Creek; Elizabethtown.	In small quantities in most of the California silver-ores.
Silver, native	Cerbat range, Ariz.; Panamint.	Rosita	
Sulphur	Coso range		
Graphite		Santa Fé, N. Mex.; Clifton.	In small quantities.
2. SULPHIDES.			
Pyrite	Cerbat range, Ariz	Rosita; Golconda and Aztec mines.	
Sphalerite	Cerbat and Inyo ranges	Golconda mine	
Stibnite	Tejon Pass		
Molybdenite	Payute district; Benton		
Chalcocite	Ivanpah, Cal.; Chukavalla Peak; Panamint; Cerro Gordo; Hualapai district; Cerbat range; Ord district; Benton.	Rosita	Often argentiferous.
Galenite	Darwin; Ivanpah; Lyttle Creek Cañon; Cerro Gordo; Chukawalla Peak.	Rosita; Golconda and Aztec mines.	Mostly argentiferous.
Cinnabar	New Almaden		
Pyrangyrite	Hualapai district, Ariz	Rosita	
Tetrahedrite	Benton	do	Argentiferous.
Argentite	Cerro Gordo	do	
Stephanite	Virginia City, Nev	do	
Sternbergite	Camp El Dorado, Nev		
Strohmegerite		Rosita	
Stetefeldite	Panamint; Ivanpah		
Realgar	Cerro Gordo		
Chalcopyrite	Hualapai district, Ariz	Rosita; Aztec mine	
3. CHLORIDES.			
Cerargyrite	Hualapai district, Ariz.; Ivanpah; Panamint; New York district.	Rosita	
Rock salt	Valley of the Lower Virgin; Death Valley; Salinas Valley; Panamint Valley.		
4. OXIDES.			
Limonite	San Bernardino Mountains	Trinidad; Gallinas Creek.	
Hæmatite	Cucamonga Peak; Cerbat range, Ariz.	Elizabeth; Baldy Mountain.	
Partzite	Benton		
Cassiterite	Timescal		
Massicot	Darwin; Cerro Gordo		Generally mixed with minium and cerussite.
Cuprite	Ord district; Hualapai district		
5. SILICA AND SILICATES.			
Quartz crystals	Cerbat range; San Bernardino Mountains.	Spanish Peaks	
Flint and hornstone	Camp Cady; Caves		
Jasper	Riverside Mountains		
Chalcedony	Cerbat range; Mohave River Valley.		Of fine amethyst-color, at Mountain Spring, in the Cerbat range.
Garnets	Riverside Mountains; Jacinto Mountains.		
Steatite	Santa Barbara County		
Zeolite	Mohave Mountains; Chukawalla Peak.		Accessory constituent of basalts.
Amphibole	Gorgonio Pass; Chukavalla Peak		
Turmaline	San Jacinto Mountains		
Muscovite	Hualapai district		In large plates.
Titanite	San Jacinto Mountains		

List of minerals and rocks collected, &c.—Continued.

COLLECTED BY OSCAR LOEW—Continued.

Minerals.	Locality in California, &c.	Locality in Colorado, &c.	Remarks.
6. SULPHATES.			
Anglesite	Cerro Gordo		
Barite		Rosita	
Gypsum	Callville; Saint Thomas, Nev	Saint Charles; Colorado Cañon.	
Soda-sulphate	Mohave River Valley; Kern Lake.		As afflorescences.
7. CARBONATES, BORATES, &C.			
Malachite	Ord district; Ivanpah; Panamint.	Coyote; Golconda and Aztec mines.	
Siderite		Rosita	
Borax	Coyote hole		
Cerussite	Darwin; Cerro Gordo		
Trona	Benton		
Calcite		Aztec mine, N. Mex.; Nutritas; Cimmarron.	
8. ORGANIC MATTERS.			
Asphaltum	Santa Cruz Island; Santa Barbara.		
Mineral-oil	San Fernando		
Lignite		Trinidad; Fort Union.	

Rocks.	Locality in Southern California and adjacent portions of Nevada and Arizona.
Granite	Riverside, Mohave, Monument, San Bernardino, San Jacinto, Opal, Payute, Cerbat and Panamint ranges.
Syenite	Mohave, Riverside, and Inyo ranges.
Mica-schist	Chukawalla and Riverside Mountains.
Gneiss	Cerbat, Riverside, San Bernardino, and Inyo ranges.
Hornblende-schist	Cerbat range, Riverside Mountains.
Diorite	Opal Mountains, Mount Newberry, Chukawalla Peak, Inyo range.
Trachyte	San Bernardino, Riverside, Mohave, Monument, Blue Ridge, Cerbat, Payute and Opal ranges, Chukawalla Peak, Mohave River Valley.
Rhyolite	Mohave range and Blue Ridge Mountains, valley of the Mohave River, Riverside Mountains.
Pyromerid	Union Pass, in the Blue Ridge Mountains.
Andesite	Payute range.
Basalt	Cerbat, Black Cañon, and Mohave ranges, Providence Mountains, Virgin River Valley, Chukavalla Peak.
Lava	Owens Lake Valley, Mohave River Valley, Black Cañon range.
Quartzite	Riverside, San Bernardino, and Panamint ranges.
Limestone	Riverside, Panamint, Inyo, and Argus ranges, Saline flats of the Mohave, Bowlder Cañon.
Conglomerates	Black Cañon range, Colorado River Valley, Providence Mountains, Mohave River Valley, San Bernardino Mountains, Opal range.
Tufa	Santa Cruz Island, Mohave range.
Sandstone	San Bernardino, Inyo, Opal and Black Cañon range, Cañon Springs, Detrital Valley.

Rocks.	Locality in Southern Colorado and Northern New Mexico.
	New Mexico.
Granite	Ute Creek. Cimarron Creek. Cieneguilla Creek. Rio Colorado Cañon. Taos range, west side. Moreno Valley. Upper Cimarron Creek. Taos range. Head of Cimmarron Creek. Colorado Cañon. Golconda mine. Costilla Mountain. Taos range, east side. Elisabeth. Baldy Mountain. Aztec mine. Rayado Cañon.
	Colorado.
	Indian Creek. Top of Culebra Peak. Top of Cerro Blanco. Head of Purgatoire River.
	New Mexico.
Granulite	Comanche Creek. Head of Cimarron Creek. Aztec mine. Uraca Mountain. Rayado Cañon.
Basalt	Hole in the Rock. Rio Hondo. Uraca Creek. Cañon of San Antonio Creek. Fort Union. Rio Grande Cañon. Rio Colorado Cañon. Ocaté Crater. Near Laughlin's Peak. Costilla Cañon.

List of minerals and rocks collected, &c.—Continued.

COLLECTED BY OSCAR LOEW—Continued.

Minerals.	Locality in Southern Colorado and Northern New Mexico.
	Colorado.
	Culebra Creek. San Luis Valley. Huerfano Butte. Head of Cucharas River. Fort Garland.
	New Mexico.
Trachyte	San Antonio Creek. Ridge of East Costilla Peak. Uraca Creek. Comanche Creek.
	Colorado.
	Near East Spanish Peak. Cerro Blanco. Gardner. Colorado Cañon. Upper Cucharas River.
	New Mexico.
Sandstone	Aztec mine. Vermijo River. Upper Cimarron Creek. Ridge north of Costilla Peak. Turkey Mountains. Costilla Creek. Moreno Valley.
	Colorado.
Feldspar-porphyry	Indian Creek.
	East side of Spanish Peaks. Rosita.
	New Mexico.
Limestone	Aztec mine. Taos range. Rio Colorado Cañon. Comanche Creek.
	Six miles from Taos. Fort Union. Elisabethtown. Collier's ranch.
	Colorado.
Diorite	Indian Creek. Saint Charles River.
	Huerfano Butte. Cerro Blanco. Cucharas River. Indian Creek. Near Walsenberg.
	New Mexico.
Hornblende-schist	Costilla Peak.
Chlorite-schist	Rayado Cañon. Elisabeth Baldy.
Conglomerate	Rayado Cañon.
Clay-slate	Fernandez Creek. Vermijo River.
Mica-slate	Elisabethtown.
Quartzite	Top of Taos Peak.
Syenite	Luero Cañon. Taos range. Rio Colorado Cañon.
	Taos Range, west side.
	Colorado.
Hornblende-porphyry	Santa Clara.
Conglomerate	Cerro Blanco.
	The following rocks were observed but not collected.
Sandstone	Wet Mountain Valley. Ryder's Cañon. Long's Cañon. Spring Vale. Huerfano Park. Walsenberg. Trinidad, Colorado. Purgatoire River. Santa Clara Creek. Bear Creek. Bodito. Cerro Blanco. Apishpa River. Arkansas River. Trinchera Pass. Cuchara Pass. Raton Plateau, Colorado. Canadian River. Rock Ranch. Cimarron River. Poril Pass. Coyote. Mora Mountain. Tierra Amarilla. Dillon's Cañon. Hole in the Rock. Aqua Negra Creek. Apache Creek. Flecha's Cañon. Ponil Park. Van Bremmer Park. Salinas Creek. Chama River, Mora River. Taos Range. Fort Union. Clifton. Santa Fé. Pecos and Abiquiu, New Mexico.
Limestone	Las Vegas. Crow Creek. Santa Fé. Rio de la Cuera. Rio de las Vacas. Pecos River. Apishpa River. And south of Arkansas River.
Basalt	Tinaja. Eagle Tail. Abiquiu. Chama River. South side Torquillo. Mesa, west of Turkey Mountains. Raton Mesa. Bragg's Cañon. Fisher's Peak. Huerfano Park.
Shale	Near Taos, New Mexico. Hole in the Rock. Aqua Negra Creek. Cuchara Pass, Colorado. Tinaja Creek.

APPENDIX H 3.

REPORT ON THE ALKALINE LAKES, THERMAL SPRINGS, MINERAL SPRINGS, AND BRACKISH WATERS OF SOUTHERN CALIFORNIA AND ADJACENT COUNTRY.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, February 7, 1876.

SIR: I have the honor to submit herewith the report on the chemical composition of the alkaline lakes and thermal and mineral springs of Southern California, visited during the field-season of 1875 by parties of your expedition.

Thus far very little had been known of the nature of these waters, and the information will, next to the scientific value, prove also very acceptable to those interested in this region.

This chapter may be considered as the continuation of the former chapters on the mineral springs of Colorado and New Mexico, published in Vol. III of the Survey Reports.

Very respectfully, your obedient servant,

OSCAR LOEW,
Chemist and Mineralogist.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in Charge.

CONTENTS.

THE OWENS LAKE, INYO COUNTY, CALIFORNIA.

This lake is, next to Mono Lake* in Mono County, California, certainly the most interesting lake on the North American Continent. Situated in a basin of about 4,000 feet above sea-level, its shores are bounded on the west side by the majestic Sierra Nevada, rising abruptly to towering peaks of 14,000 to 15,000 feet; and on the east side by the precipitous Inyo range, with the famous mines of Cerro Gordo and an altitude of 10,000 feet. Standing on the summit of this range, the panorama spread out in all directions is one of the grandest, most overwhelming views to behold, although there is no verdure to delight the eye and to support the ornamentation of the scenery. How far beneath us lies the Salinas Valley on one side, the Owens Valley on the other! How perpendicular the mountains, how diminutive the lake! How are we deluded by the optic refraction of the superposed strata of air of different temperature! Truly, to observe the setting sun on these heights, the changing tints of the sky, the spreading of darkness over peaks and valley, is a spectacle never to be forgotten.

The Owens Lake has no outlet and is fed by the Owens River, a stream about 30 feet wide, 2 feet deep, and having a velocity of about 5 miles per hour. As the level of the lake remains constant, there must be a perfect equilibrium between the amount of evaporation and the incoming water. The lake having 110 square miles surface, an evaporation of 4.6 feet per year would suffice to swallow up the annual volume of Owens River. Those who cannot appreciate the amount of evaporation, have invented the hypothesis of a subterranean outlet, as in the case of Great Salt Lake in Utah. The water has a strong saline and alkaline taste, and is far-famed in Mono and Inyo Counties for its cleansing properties, surpassing those of soap. Neither fish nor mollusks can exist, but some forms of lower animal life are plentiful, as infusoriæ, copepoda, and larvæ of insects.

While *around* the lake the vegetation consists of two salt plants, Bryzopyrum and Halostachys, the vegetation *in* the lake is confined to an algous or fungoid plant, floating in small globular masses, of whitish or yellowish-green color in the water. These accumulate on certain localities of the lake-bottom and near the shore and undergo decay, emitting a feces-like odor, as observed also in the treatment of albuminous matters with caustic alkalies.

One of the most striking phenomena is the occurrence of a singular fly, that covers the shore of the lake in a stratum 2 feet in width and 2 inches in thickness, and occurs nowhere else in the county; only at Mono Lake, another alkaline lake, it is seen again. The insect is inseparable from the alkaline water, and feeds upon the organic matter of the above-named alga that is washed in masses upon the shore. In the larva state it inhabits the alkaline lake, in especially great numbers in August and September, and the squaws congregate here to fish with baskets for them. Dried in the sun and mixed with flour, they serve as a sort of bread of great delicacy for the Indians.

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* This lake is said to resemble the Owens Lake in all particulars.

Humboldt relates that, in Mexico, the dried larvæ of an insect from the lake Tescuco, form an article of commerce among the Indian population of the province.

Notwithstanding the alkalinity of Owens Lake, numerous ducks are occasionally seen swimming on it. The great numbers of dead ducks and other aquatic birds seen here and there on shore seem to indicate that they tried to satisfy their thirst with this water.

In regard to the fly-species, an interesting letter from Baron Osten-Saken may be referred to here, to whom were sent a few specimens for examination. He says: "They belong to the genus Ephydra, but differ in some respects from the usual type of the genus. Usually, Ephydræ are of a metallic blackish-green, while the species in question is dead gray, and not metallic at all. Other differences may be revealed on a more careful examination. Several species of Ephydræ have been observed to live in the larva state in salt water, either in the brackish waters near the shore, or in the brine of salt-works. A species of Ephydra occurs in enormous numbers on the shore of the Great Salt Lake, Utah. I am pretty sure that it is a species different from yours; next summer I hope to ascertain the fact positively."

I had suspected the peculiar algæ of Owen's Lake a new species, and sent a specimen to Professor Wood in Philadelphia for examination; unfortunately, however, I was not favored with an answer.

The lake was evidently at one time much larger than at present, and its waters pure and fresh, so as to permit the life of various fresh-water mollusks, as indicated by numerous shells of recent species found in the sand of the vicinity.* Upturned strata of limestone and slate, containing numerous dikes of intrusive rock, as diorite and porphyry, skirt the valley of the lake on the east side, while the main mass of the opposite Sierra Nevada consists of granite and gneiss.

The taste of the water reveals at once the presence of carbonate of soda. The specific gravity is 1.051. In 100 liters (= 26.42 gallons) are contained:

	Grams.
Potassium sulphate	644.87
Sodium sulphate	929.07
Sodium carbonate	2,440.80
Sodium chloride	2,328.30
Silicic acid	17.21
Boric acid	traces.
Phosphoric acid	traces.
Nitric acid	traces.
Lithia†	traces.
Lime	traces.
Magnesia	traces.
Aluminia	traces.
Organic matter	traces.
	6,360.25

The proportion of saline substances is therefore over double as large as in sea-water, and about one-third of that of the Great Salt Lake. But while these contain chloride of sodium, the former contains a large amount of carbonate of soda. To undertake to calculate this for the whole lake is to appreciate its value. The greatest length is 17 miles; width, 9 miles; depth, 51 feet. The total surface of the lake is very closely 110 square miles = 284.9 square kilometers, the average depth 3 meters = 9 feet 10 inches. The cubical contents are therefore = 0.8547 cubic kilometers.

One cubic kilometer = 1,000 × 1,000 × 1,000 cubic meters.

One cubic meter = 1,000 liters.

Hence the volume of the lake = 854,700,000,000 liters or = 8,547,000,000 hectoliters.

As the analysis shows, one hectoliter contains 2.44 kilograms carbonate of soda, hence the total amount in the lake = 20,854,680,000 kilograms, or 22,000,000 tons.‡ Evaporation and concentration works might be erected at a moderate cost, and the carbonate of soda separated by crystallization from the remainder of the salts. If by this process also the considerable amount of potassa, which is a valuable fertilizer, were separated and saved, the outlay for fuel might be compensated. Wood is scarce in the vicinity, and transportation at present expensive, which would be modified with the completion of the projected Independence Railroad. The analysis showed that there is one-twentieth more carbonic acid than required to form with the available soda the monocarbonate; hence there is a small amount of bicarbonate present, which, however, was calculated in the analysis as monocarbonate. The amount of bicarbonate formed depends upon the quality and tension of the carbonic acid coming in contact with the monocarbonate, also upon the quantity of water. Another fact to be men-

* I find this fact also mentioned by G. K. Gilbert, vol. III, Survey Reports.

† Careful search was made for traces of rubidium and cæsium, according to the method of Bunsen, but no trace was revealed by the spectroscope.

‡ The amount of sulphate of potassa would be 5,000,000 tons.

tioned is the formation of a considerable quantity of sulphide of potassium and sodium, if the water is kept in well-corked bottles for several months, in the dark. 100cc of such water were mixed with ammoniacal cuproammonium sulphate and 0.024 grams sulphide of copper obtained, corresponding to 0.019 grams sulphide of sodium. Of course there was no longer any free oxygen present in this bottle, but still the animal life was not extinct, and the minute copepoda were soon in agitation, when the water was poured in a large airy bottle and exposed to sunlight. It is astonishing under what circumstances life sometimes can exist, and a world of mysteries still lies here before us, waiting to be solved by future investigators.

THE BLACK LAKE OF BENTON, MONO COUNTY, CALIFORNIA.

About one mile west of Benton, a little mining town in Mono County, California, rises a low granite hill-chain, running from north to south, and bordering a long-stretched valley with its western slopes. In this depression a number of springs and grassy spots are met with.

In the northern portion of this valley is situated a lake of about 1 mile in length, varying in width from 100 to 500 feet, and reaching a depth of 60 to 70 in some places. It is called the Black Lake, on account of the dark color of its water—a coloration due to its containing organic matter in solution. The taste is strongly alkaline, and white efflorescences are seen all around the lake. The amount of saline constituents is much smaller than at Owen's Lake, and to this fact it is due that Black Lake does not prevent several species of juncus and gramineac from growing in the shallow places, nor permits the existence of the peculiar black fly found at Owen's Lake. Like the latter was also Black Lake formerly much larger, and formed, doubtless, the drainage-basin of a number of hot alkaline springs, like one still in existence in the vicinity. Many hot springs also exist in Long Valley, 25 to 30 miles west of Benton. Another small alkaline lake is the Slough, near Bishop's Creek.

The water of Black Lake gave the following composition. In 100 liters are contained—

	Grams.
Sodium carbonate	1,233.1
Sodium sulphate	294.0
Potassium sulphate	83.5
Sodium chloride	234.2
Silicic acid	5.2
Formic acid	traces.
Humic and crenic acid	traces.
Phosphoric acid	traces.
Boric acid	traces.
Iodine	traces.
Bromine	traces.
Lithia	traces.
	1,850.0

THE WATER OF THE VIRGIN RIVER, (SOUTHERN NEVADA.)

This tributary of the great Colorado penetrates a wide valley, of over 25 miles in length, before it empties into the latter. Not a single settlement exists in this apparently very fertile bottom—a fact that is understood as soon as the water of this river or of any well sunk in the valley is tasted, it being not only very disagreeable, resembling in taste glauber and epsom salts, but its effects are of an alarming nature, diarrhœa and vomiting being the immediate consequences of having tried to satisfy the burning thirst by means of this water. Cattle using it for a few days in succession invariably die; also many human beings become sacrificed to it. Hence the water is pronounced poisonous, and people avoid settling in this valley.

The chemical analysis did not reveal a trace of mineral poisons, but the presence of a large amount of sulphates, to which the diarrhœa must be ascribed. It is easily understood how deleterious in such a hot climate, when the body is weakened considerably, a diarrhœa must prove.

The following was found to be the composition:

In 100 liters of the water are contained—

	Grams.
Potassium sulphate	4.16
Sodium sulphate	94.71
Calcium sulphate	73.60
Magnesium sulphate	75.66
Sodium chloride	189.00
Total	437.13

Alumina, iron, and phosphoric acid were present in small traces.

While these salts are contained in solution, a reddish mud is kept in suspension, its average quantity being 170 grams per 100 liters.

THE SALT-WELL NEAR STONE'S FERRY, (SOUTHERN NEVADA.)

About 1 mile north of Stone's Ferry, and some 3 miles west of the junction of the Virgin with the Colorado, exists a singular sink, with a surface of 600 square feet and a depth of 96 feet.* It is situated in a funnel-shaped depression in the mesa, and the sink can only be reached after a careful descent of about 30 feet on the steep slopes of this funnel. As there are deposits of rock-salt in the vicinity, this singular natural well obtains its salty constituents probably from them.

The temperature on the surface was 89°.5 F., that of the air being 105° F. at the same time, August 5. The composition of the water was found to be the following:

Sodium chloride	1,813.50
Sodium sulphate	294.71
Calcium sulphate	172.04
Magnesium chloride	48.27
Aluminium chloride	trace.
Silicic acid	trace.
	2,328.52

THE THERMAL SPRINGS OF SANTA BARBARA, CALIFORNIA.

These springs are situated 6 miles west of the town of Santa Barbara, in two cañons of the Santa Inez Mountains, and in an altitude of 1,415 feet above sea-level. The steep slopes of the mountains and the fine view of the ocean and the islands near the coast render the locality very picturesque. A hotel and bath-houses exist near the springs for the accommodation of guests.

The springs number in all twenty-two, and their temperature ranges from 112° to 122° Fahrenheit. A taste is hardly perceptible; the odor very faint after sulphureted hydrogen. Issuing from fissures of a fine-grained, very hard and dense sandstone, they form pools and rills, covered with an alga of a vivid green; also, a small violet fungus can be noticed. Two specimens of springs were analyzed; No. 1 from Hot Spring Cañon main spring; No. 2 from main spring in the side cañon. In 100,000 parts of water are contained, parts—

	No. 1.	No. 2.
Sodium carbonate	29.6	24.8
Sodium chloride	8.7	7.6
Sodium sulphate	5.0	trace.
Silicic acid	4.2	6.0
Calcium, potassium	traces.	traces.
Sulphureted hydrogen	traces.	traces.
Free carbonic acid	traces.	traces.
	47.5	38.4

THE HOT SPRINGS OF SAN BERNARDINO, SOUTHERN CALIFORNIA.

Seven miles north of the town of San Bernardino, in the foot-hills of the mountains, quite a number of thermal springs take their rise. The place can be easily recognized from afar by a peculiarly-shaped large barren spot on a steep hill-side, bearing resemblance to the "ace of spades," by which term the hill is known to the people of the town. The spot was probably produced by a land-slide. A homeopathic physician, who keeps his guests and patients on vegetable diet, has established a small hotel at the springs for accommodation of about a dozen people, and erected a few bathing-houses. He also formed a large basin for the reception of the hot water of the spring, next to the house.

The formation of the vicinity consists of granite and gneiss, and from fissures in these rocks issue the hot springs, about a dozen in number, and of a temperature from 154° to 210° F. They emit no peculiar odor. Around the rim of the basins efflorescences both ochry and white are formed. The taste of the springs is very weak, being nearly that of plain water.

Two specimens of waters were procured; No. 1 from the large spring in front of the hotel, and No. 2 from the spring 200 yards west of the hotel, near the bath-house.

* The depth was ascertained by the topographers of our party, Thompson and Birnie, who swam with a twenty-pound weight to the center of the well and sunk it to the bottom. These gentlemen also determined the level of the well to be the same as the Colorado River.

In one hundred thousand parts of water are contained—

	No. 1.	No. 2.
Sodium sulphate	81.7	80.2
Potassium sulphate	2.3	trace.
Sodium chloride	12.8	13.4
Carbonate of lime	10.7	11.0
Carbonate of iron	trace.	trace.
Carbonate of magnesia	trace.	trace.
Silica	20.5	22.4
Total	128.0	127.0

It will be noticed how closely both springs agree in their composition. Carbonate of soda, a usual compound met with in the hot springs of California, is absent, but silica is there in increased proportion. Indeed, on evaporating the water I noticed quite a jelly-like separation of the silicic acid before the residue became perfectly dry.

THE THERMAL SPRINGS OF SAN JUAN CAPISTRANO, SAN DIEGO, CALIFORNIA.

In the cañon of the Rito de la Mission Vieja, 12 miles east of the village San Juan Capistrano, are situated six thermal springs, issuing from fissures of the Azoic rocks. The locality looks like an inviting hidden mountain summer resort.

The Tertiary and Quaternary formations so conspicuous around the town of San Juan Capistrano, cease as we ascend the foot-hills of the mountains. The springs belong to an old grant, whose owner refuses permission to build a hotel at the springs, although sums of money have been offered to him. He hates monopoly, and wants free access for every one, even the poorest, to the springs. Hence any person who wants to stay here for some time has to provide himself with blankets and a cooking outfit; and many a diseased man of means learned here for the first time, how much healthier it is to sleep under a tree than in the best furnished hotels. There are sometimes twenty to thirty persons camping in the valley; some have tents, others a few branches under which to sleep. Some of the springs form pools that are used for bathing purposes. At the time of my visit I found six individuals there shut out from the rest of the world, and living upon bread and bacon.

There exists one cold spring of 3 to 4 square feet surface, a temperature of 75° F., and a faint odor of sulphureted hydrogen. The hot springs form no deposit worth mentioning, have but a very faint odor, and are nearly insipid. The temperature of these six springs was found 120° to 123° F. A specimen of water of the main spring was procured for analysis. There are three other hot springs half a mile north of the lower group, and one of them contains a trace of iron.

The main spring furnished the following result. In one hundred thousand parts of water are contained parts—

Sodium carbonate	11.10
Sodium chloride	10.53
Sodium sulphate	trace.
Silicic acid	7.66
Lime	trace.
Magnesia	trace.
Potassa	trace.
Lithia	trace.
	29.29

The healing properties of this water can only be ascribed to their temperature or to a sympathetic belief.

HOT SPRING OF THE CABEZON VALLEY.*

Some 10 miles south of White River exists *Aqua caliente*, a little oasis with a hot spring. This spring has 1½ to 2 square feet surface, and discharges its water into a large pool, which is used by Indians as a bathing-place. The water has 100.4° F., of a weak smell of sulphureted hydrogen, and is almost tasteless. On chemical analysis, the amount of mineral matter was found indeed but very small.

In one hundred thousand parts of water are contained—

Sodium chloride	31.0
Sodium sulphate	trace.
Sodium carbonate	8.3
Lithia	trace.

*This valley, also called Coahuilo Valley, is a long-stretched basin in Southeastern California, south from the San Bernardino Mountains.

Lime	trace
Magnesia	trace.
Silicic acid	trace.
Organic matter	trace.
Sulphureted hydrogen	trace.
	39.3

WARM SPRING, NEAR LITTLE OWENS LAKE, INYO COUNTY, CALIFORNIA.

A sample of this water was collected by Lieut. R. Birnie, jr., of division No. 2, of your expedition, who kindly furnished me with the following notes:

The spring is situated 300 yards from Little Lake, near a basaltic bluff 20 to 30 feet in height, and extending north to south several miles. The water is lukewarm, odorless, and forms no deposits or incrustations. A mineral taste is hardly perceptible.

The following is the composition:

In one hundred thousand parts are contained parts—

Sodium carbonate	45.2
Sodium sulphate	8.0
Sodium chloride	26.9
Calcium carbonate, with trace magnesium carbonate	12.0
Organic matter	trace.
Potassium, Silicic acid,	traces.
Total	92.1

Here may be the proper place to mention that the water of Little Owens Lake (also called "Little Lake") is not brackish, nor charged with mineral salts, like Owens Lake, Black Lake, and Mono Lake, according to information I obtained from Lieut. R. Birnie, jr.

THERMAL ACID SPRINGS, IN THE COSO RANGE, INYO COUNTY, CALIFORNIA.

These singular springs, situated in the Coso range, 12 miles east of Little Owens Lake, are the discovery of Lieut. R. Birnie, jr., of your survey, through whose kindness I was provided with information regarding them and with several bottles of water for analysis. They have but a limited flow, and form pools through which steam is continually ejected. Large deposits of sulphur (the specimen I received from Lieutenant Birnie was a solid chunk of nearly pure sulphur) cover the surroundings, and hundreds of tons of this material are said to exist in the neighboring mountains, where extinct and living thermal springs are numerous.

The taste of the water is intensely *sour*, making it perfectly unfit for drinking purposes. It has no smell, but formerly there must have been large quantities of sulphureted hydrogen contained in it, as the sulphur deposits indicate. It is true, I found a large proportion of *free sulphuric acid* in these waters, but the sulphur deposits cannot be derived from this source. Chemists are, at least, unacquainted with a process by which free sulphuric acid would turn under the circumstances, as the above, into sulphur.

The composition is certainly a remarkable one, as will be seen from the following analysis:

In one hundred thousand parts of water are contained parts—

Free sulphuric acid	78.4
Potassium sulphate	2.5
Sodium sulphate	15.1
Calcium sulphate	15.3
Magnesium sulphate	1.2
Aluminium persulphate	127.0
Iron persulphate	33.2
Nitric acid	traces.
Phosphoric acid	traces.
Chlorine	traces.
Ammonia	traces.
Lithium	traces.
	272.7

Springs or lakes of a chemical composition like this are very rare. I know only of one instance analogous to it; that is the "Sour Lake" in Texas. Singular is also the small trace of chlorides in a water so strongly charged with mineral matters.

P. S.—Quite recently Boussingault has discovered and analyzed quite analogous springs in the vicinity of the volcanoes of the South American Cordilleras de los Andes. (Annales de chimie et de physique, 1875.)

THE SULPHUR SPRING ON THE SOUTH SIDE OF SAN FERNANDO MOUNTAIN, LOS ANGELES, CALIFORNIA.

For the water of this spring collected by yourself, and for the following information I am indebted to you.

The spring issues upon the eastern side of a little cañon, coming out of the southern portion of the San Fernando Mountains. Its first superficial reservoir in the surface-rock, which is of Tertiary age, is surrounded by recent deposits formed by the spring. The water is higly charged with sulphureted hydrogen. Its healing properties are well known, and made use of by the Indians, who, led by their priests, used to make pilgrimages from the old San Fernando Mission to this spring.

In one hundred thousand parts of water are contained parts—

Sodium carbonate	6.21
Sodium sulphate	23.87
Sodium chloride	trace.
Calcium carbonate, mangnesium carbonate	*50.60
Silicic acid	trace.
Phosphoric acid	trace.
Carbonic acid	in excess.
Sulpureted hydrogen	5.
Potassium, lithium, manganese, iron, alumina	traces.
Organic matter	trace.
Total	85.68

LITTLE YOSEMITE SODA SPRING, KERN COUNTY, CALIFORNIA.

Water of this spring was collected by Mr. F. Klett, to whom I am indebted, also, for the following information:

The spring is situated in the valley of the north fork of Kern River, whose calcareous ocher-colored deposits of great extent, indicate the former activity of a large number of mineral springs, of which those in existence at the present day form apparently only a small remnant. The Little Yosemite Soda Spring bubbles continually, emits no odor, has an exceedingly agreeable taste, and a temperature of 52° F. Animals prefer this mineral water to that of the Kern River, which is but 50 feet distant. The vicinity has a luxuriant vegetation. To all appearances, this will become a popular summer resort in the future.

In one hundred thousand parts of water are contained parts—

Sodium carbonate	20.97
Sodium sulphate	trace.
Sodium chloride	4.68
Calcium carbonate, with some magnesium carbonate	16.02
Iron carbonate	0.92
Silicic acid	7.31
Free carbonic acid	in excess.
	49.90

MINERAL SPRING OF ENCINO RANCHO, SAN FERNANDO VALLEY, LOS ANGELES COUNTY, CALIFORNIA.

Water of this spring was obtained by you for chemical investigation, and the following notes by Mr. F. Klett:

The spring is situated fourteen and a half miles from Los Angeles, on the Santa Barbara and San Buenaventura stage-road, and is the property of Mr. Garnier, the owner of Encino Rancho. The temperature was found 85°.5 F. at 7 a. m., and 87° F. in the afternoon, a change due to the effects of the exposure to the sun. The flow is about five gallons a minute. A basin of masonry about 12 feet in diameter contains the water, which rises at uneven intervals, as indicated by a great number of bubbles thrown up. A bathing reservoir is connected with the spring. The water is used for irrigating purposes on the ranch.

In one hundred thousand parts of water are contained parts—

Sodium carbonate	24.31
Sodium sulphate	54.46
Sodium chloride	2.93
Calcium carbonate, with some magnesium carbonate	32.17
Silicic acid	11.50
Phosphoric acid	trace.

* Present as bicarbonates in solution, but deposited on ebullition and concentration of the liquid.

Sulphureted hydrogen	trace.
Potassium	trace.
Lithium	trace.
Carbonic acid	in excess.
	125.37

THE THERMAL SPRING OF BENTON, MONO COUNTY, CALIFORNIA.

A few rods west of the small mining settlement of Benton issues a hot stream of considerable size, from the fissures of the granite. This rock is overlaid by volcanic tufa. The basin has 3 to 4 feet in diameter, and a depth of half a foot, and the water comes up with such force and quantity that I think a yield of 200 gallons per minute is not an overestimate. From the good-sized creek thus formed, a ditch carries the water to the town, where it is used for drinking and household purposes, as it is almost tasteless. That, however, some mineral matter must exist in solution, may be inferred from the fact that the rocks near the spring show white incrustations and efflorescences. No medical use is made of the spring; its temperature is 138° F., but it is said that variations up to five degrees have been noticed. It contains in one hundred thousand parts but 26 parts mineral matter, consisting of sodium carbonate, sodium sulphate, sodium chloride, with traces of potassium and calcium salts.

MINERAL SPRING OF LYTTLE CREEK CAÑON, SAN BERNARDINO COUNTY, CALIFORNIA.

The Lyttle Creek Cañon is situated on the eastern slopes of the San Antonio Peak in the San Bernardino Mountain range, and runs parallel with the road across the Cajon Pass for some distance. Three miles above the mouth of the cañon we have another side cañon, which comes in from the west. In it is situated a spring, with a large basin of about 25 square feet, but with a very moderate flow. The taste is very faint, the odor slightly after sulphureted hydrogen; bubbles of carbonic acid are continually rising from the bottom. The temperature was found to be 92° F., that of the air being 94° F. (June 30, 2 p. m.)

While the cañon is filled with trees and shrubbery, there are but few patches of arable area. Besides the few men engaged in the hydraulic-mining works in the vicinity, only two men, living like solitary hermits, inhabit the cañon.

In one hundred thousand parts of water are contained 56.8 parts solid material, consisting chiefly of sodium carbonate, sodium sulphate, sodium chloride, with traces of calcium carbonate and silicic acid.

SPRING OF THE DOS PALMS OASIS, COAHUILA VALLEY, DRY LAKE, SAN DIEGO COUNTY, CALIFORNIA.

Where the road from Ehrenberg, Ariz., to San Bernardino, Cal., enters the Big Dry Lake, a small oasis exists, prominent by two palm-trees that grow here in a wild state. The spring that furnishes the water for the pond at which these palms are growing, is but a few yards distant from the hut of the single inhabitant of this oasis. As far as the water of this oasis spreads, the salt grass—*Bryzopyrum spicatum*—grows abundantly, but farther on nothing is seen but barren clay, covered with salt efflorescences.

The whole basin was a great lake until quite a recent period.

The spring of Dos Palms has a disagreeable, brackish taste, a temperature of 82° F., and is odorless.

In one hundred thousand parts of water are contained parts—

Sodium chloride	230.8
Calcium sulphate	32.6
Magnesium sulphate	31.0
Calcium carbonate	traces.
Manganese	traces.
Phosphoric acid	traces.
Silicic acid	traces.
	294.4

WATER FROM THE SALINE FLATS OF THE MOHAVE RIVER OR SODA LAKE, SAN BERNARDINO COUNTY, CALIFORNIA.

These names are given to a flat basin 14 miles long and 4 to 5 miles wide, and surrounded by chiefly volcanic ranges. The bottom is composed of clay, devoid of vegetation, but covered with patches of saline efflorescences. Here the Mohave River rises for the last time in its remarkable course, which is repeatedly a subterranean one, and forms here but a small rill of water.

While this river in its upper course has no saline taste of any consequence, it has acquired here a disagreeable taste of Glauber salts; still it is the only water that may be drank in that whole region. While it has no smell in the fresh state, the sample

taken developed on boiling a disagreeable odor of crude hippuric acid. The presence of organic matter in the water cannot be a cause of surprise to any one who saw the great number of dead sheep lying in the stream, 12 miles farther up, where the river gradually sinks to re-appear at Soda Lake. But, strange to say, putrefaction does not set in so long as this water, after its subterranean course of 12 miles, is exposed to the desert air, and is not brought into too close vicinity with the decaying animal-matter.* This speaks well for the scarcity of the bacteriæ and other ferment-producing organisms in the desert air. The water has, after concentration, a slight acid reaction.

In one hundred thousand parts of water are contained—

Sodium chloride	170.8
Sodium sulphate	63.1
Calcium sulphate	21.2
Magnesium sulphate	8.5
Organic matter	19.0
Potassium	traces.
Lithium	traces.
Phosphoric acid	traces.
Silicic acid	traces.
	282.6

BITTER SPRING FROM MINERAL PARK, ARIZONA.

There are a number of springs in the vicinity of the little mining settlement of Mineral Park, situated in the Cerbat range in Northern Arizona, which have a disagreeable, bitter taste, making the water unfit for drinking or culinary purposes, and compelling the population of the town to procure potable water from a cañon 4 miles distant. Where the water of these bitter springs passes across rocks, it coats them gradually with a thin film of oxide of iron and manganese. It is neutral to test-papers, and on evaporation much gypsum is deposited.

It contains in one hundred thousand parts—

Calcium sulphate	118.5
Magnesium sulphate	65.3
Magnesium chloride	5.4
Sodium sulphate	trace.
Manganese sulphate	trace.
Iron sulphate	trace.
	189.2

No trace of potassium or lithium was found.

Another bitter spring, but not so strongly charged with salts, exists on the trail from Callville to Saint Thomas, Southern Nevada.

THE GYPSUM SPRING, NORTHWESTERN ARIZONA.

This spring is situated in a big dry wash that leads from the Detrital Valley to the Colorado River, which forms there the boundary-line between Arizona and Nevada. White soft crusts, for some distance from the spring, indicate that the water is charged considerably with mineral constituents. It has a faint odor of sulphureted hydrogen, and a strong saline and disagreeable taste. The geological formation, in which the spring is situated, consists of a red triassic sandstone, and conglomerate with gypsum and salt deposits.

To one hundred thousand parts of water are contained parts—

	I.	II.
Sodium chloride	397.8	12.23
Sodium sulphate	51.6	
Magnesium sulphate	172.8	23.73
Calcium sulphate	130.1	7.22
Calcium carbonate	12.0	74.80
Potassium chloride	trace.	13.44
Magnesium carbonate	trace.	9.62
	764.3	141.4

I have added here under II the composition of a spring from Kerami, in the Lybian Desert, of which a specimen was collected by the traveler G. Rholfs, and analyzed by T. Hessert, (Ann. de Chim., 1875.)

* Thousands of sheep die annually while driven through the desert into Arizona. Their decay is due not to bacteriæ of the desert, but to those in their bodies.

CONCLUSION AND REMARKS.

On subjecting the surface-conditions of California to a critical examination, one cannot fail to be struck forcibly by the great number of thermal springs; indeed, there are few countries in the world with such a large number upon an equal area. It is true, Montana and Idaho, with the famous geyser-regions, first explored by Lieut. W. Doane—then Colorado and New Mexico—contain also a considerable number, and still above them Nevada; but these Territories have more or less similar features as California in regard to the extensive volcanic formations. There is no doubt that a close connection exists between the latter and the thermal springs; both are due to the fact that the earth-crust covering the molten interior is thinner than elsewhere. Waters, after penetrating this crust, become heated, charged with salts, and are driven through other fissures to the surface by the power of the generated steam.

In connection with this relatively thin crust stands the great number of earthquakes felt annually in California. Alexander von Humboldt says, in the description of his travels through the equatorial regions of South America, that "the hypothesis of the relation between the volcanic formations and the existence of th ermal springs seems not to be well founded;" simply because he encountered springs of nearly boiling temperature issuing from *Azoic rocks* at Mariara, on the Orinoco. He certainly would have formed a different opinion had he traveled through New Mexico, Nevada, and California, where gigantic peaks and wide-spread flows of *volcanic* material form most prominent features. It may safely be assumed it is rather the exception that thermal springs issue within very large distances from volcanic formations.

In Southern California thermal springs are found at Santa Barbara, San Juan Capistrano, San Diego, Yuma, San Bernardino, Benton, in Coahuila Valley, Long Valley, Death Valley, Panamint Valley, Salinas Valley, in the Coso Range, at Kernville, and Caliente. A number exist also in Northern California, among them several far-famed geysers.

Strange to say, most of these thermal waters contain comparatively small quantities of mineral constituents; indeed, less than many of New Mexico. Generally they contain carbonate of soda, a notable exception from those of San Bernardino; this salt is accompanied by sulphate of soda and chloride of sodium, in varying proportion. Carbonate of lime, with some carbonate of magnesia, form, in most of the cases, an additional mixture, while silicic acid never is wanting entirely; its quantity, however, is not considerable. As a general rule, the amount of potassium salts falls far behind that of sodium salts, which is probably due to the fact that the former are retained by the strata traversed. It is well understood how quickly potassium salts are absorbed by the soil in such a manner that water cannot wash them out.

One of the most remarkable thermal springs is that discovered by Lieut. Rogers Birnie, jr., heretofore mentioned. It has an intensely sour taste, due to free sulphuric acid, and, besides, it contains the sulphate of potassa, soda, lime, magnesia, alumina, and oxide of iron. The presence of small quantities of nitric acid and ammonia may be due to the formation of ammonium nitrite from water and nitrogen of the air, and to the immediately following combination of the ammonia with the sulphuric acid; thus the redecomposition of ammonium nitrite, taking place so readily under ordinary circumstances, being prevented.

With regard to the cold mineral springs, that of the Little Yosemite deserves especial mention, being the only soda spring with a notable quantity of iron. Next to this one, the soda spring of Encino Rancho, and the sulphur spring of San Fernando Mountain, are of medicinal value.

The brackish and bitter springs generally contain sulphate of magnesia, sulphate of soda, sulphate of lime, and chloride of sodium or magnesium; these waters, although mineral springs in a wider sense, are repulsive to taste, and men and animals avoid to drink of them, while springs of a character like that of the Little Yosemite are eagerly drunk, and preferred even by animals to ordinary water. The Mohave Desert, like many other deserts, abounds in such bad waters, the horror of the tired, thirsty traveler. Bitter springs and brackish waters were encountered in the mountains 20 miles north of Callville, in Southern Nevada, at Miningtown Mineral Park, in Northwestern Arizona, at Dos Palms, and thence 5 miles west from there, in San Diego County, on the saline flats of the Mohave, and, above all, in the Virgin River.

A fact of no little interest is the occurrence of a number of lakes in Eastern California that contain as main constituent carbonate of soda. These lakes, and a number of alkaline and saline flats, are situated east of the Sierra Nevada, and west of the great parallel ranges known as the White Mountains, Inyo and Argus ranges, which are filled with splendid fissure-veins. The alkaline lakes are Owens Lake, Mono Lake, Black Lake, and the slough of Bishop Creek.

In addition to this chapter, the notes on mineral and thermal springs visited by Mr. Douglas A. Joy, who was attached as geologist to the Division No. 2, in command of Lieut. W. Whipple, may find a suitable place. To Mr. Joy I am indebted for the following communication:

The first spring met with was near that at Encino Rancho. A pipe has been sunk in the rock, and the water rising in it fills an octagonal stone tank of about 10 feet diameter and 12 feet deep. It overflows at the top and runs into an artificial pond. I do not know at what depth the pipe was sunk, but undoubtedly deep enough to pierce the Tertiary (Pliocene?) limestone, dipping here from the mountains toward the plain.

The next mineral spring met with was in a cañon leading from Montan's ranch to Cespe Creek Cañon. It is 8 miles below the ranch and about 4 miles from the junction of the two cañons. The water issues through four or five fissues in the granite, one of them about 20 feet above the bottom of the cañon. Steam rises in thick clouds from the rocks, and has a peculiar odor. The rocks over which the water first flows are stained deep black, while those farther down in the stream have a bright red iron color. I do not know how to account for the black color unless it be a deposit of peroxide of manganese. The yield of water is about thirty gallons per minute, and its temperature was found 195° F.

In the Ojai Valley, about 6 miles from its junction with the Santa Clara Valley, there are a number of natural petroleum springs. A well sunk yielded two gallons per minute.

About 7 miles below Kernville, following the river, there is a hot spring, claimed to be a sulphur spring, but evidently is not, as it failed to blacken a bright silver coin left in the water for over half an hour. The temperature was 127° F., whilst the temperature of a spring not ten yards distant was only 70° F. The flow is about ten gallons per minute, the formation of the vicinity granite. A bath-house has been erected, and invalids suffering from rheumatism and other diseases come here for cure.

At a place called Agua Caliente, which is about 30 miles from the town of Caliente, there is a warm sulphur spring. The water bubbles up through the soil in numerous places. The largest spring has been dug out and is used by the Indians for washing and bathing. A bright silver coin is blackened almost immediately when dropped into this water. The temperature was 80° F., and the flow not more than two gallons per minute.

Another mineral spring was met with near the head of Walker's Basin. It issues from granite, and has a temperature of 100° F.; the flow is about three gallons per minute. A ranchman who lived near by built a little bath-house at the spring.

APPENDIX H 4.

REPORT ON THE GEOLOGY OF THE MOUNTAIN RANGES FROM LA VETA PASS TO THE HEAD OF THE PECOS, BY A. R. CONKLING.

NEW YORK CITY, *April* 25, 1876.

SIR: Beginning at the La Veta Pass and proceeding south, the mountain ranges will be described in the following order: Spanish Peaks, Culebra range, Cimarron range, Taos range, Mora range, Santa Fé range, and Las Vegas range.

The Spanish Peaks form a minor range about 10 miles long. The peaks are two pyramid-shaped mountains and consist of pinkish trachyte. Perpendicular walls of trachytic rock diverge from the Spanish Peaks, extending into the plain for more than a mile in some cases. The walls are in general about 100 feet high. The top of the walls is flat and the jointed structure is well shown in them. In places these walls have fissures—breaks in the form of right angles, thus presenting the appearance of trap rocks. These rocky walls are dikes of trachyte upheaved through huge fissures in the earth's crust after the greater part of the Spanish Peaks had been formed. About 3 miles north of west Spanish Peak is a curious butte of basalt, having the form of a tower with a rounded top. The butte is about 250 feet high and stands alone in the midst of a plain. I propose the name La Torre for it. The south fork of the Cucharas River flows between the Spanish Peaks and the Culebra range. The river has cut its way through a steep wall of gray sandstone running north and south, but forming a break in the wall large enough to admit the passage of a wagon-road which is much used by the settlers. This gap is called the "shut in."

At Willis ranch, on the north side of the Cucharas, a ledge of fine-grained drab limestone outcrops, but I was unable to define the limits of it.

Following up the stream to the divide and a little beyond to the headwaters of the Purgatoire, the country is covered with a series of anticlinal ridges of white and yellowish sandstone with vertical joints, which rest on granite. The Spanish Peaks may be regarded as an outlier of the Culebra range, which will now be described.

The Culebra range extends from Trinchera Pass on the north to Costilla Creek on the south. The predominating rock is grayish granite. Hornblende porphyry occurs at various points. A series of low foot-hills of basalt bound the Culebra range on the west side, forming a portion of the plateau through which the Rio Grande runs.

No sedimentary rocks were observed in the Culebra range. Ore deposits are found at but one locality in this range, viz, one mile east of Culebra Peak. Mr. E. D. Bright, of Trinidad, Colo., who visited this locality informs me that there is a vein of quartz-bearing silver 7 feet wide running through hornblendic granite. The ore assays $75 a ton. Another locality 4 miles east of this point has been discovered where the ore yields 52 per cent. of copper and 6 ounces of silver to the ton. The granite forming the summit of the Culebra Peak contains a large amount of feldspar. The rock is traversed by numerous joints and fissures. It has also undergone much disintegration, and a large number of detached fragments is the result. Jasper is found in small quantities on top of Culebra Peak. There are three peaks south of Culebra that probably consist of granite, but I did not visit them. The rock in these peaks is colored red by oxidation of the iron. The range then trends southwest, and low ridges of sandstone appear for 15 miles south to Costilla Peak. The ridges slant gradually in going south. They are formed of a fine-grained yellowish sandstone that sometimes passes into a coarse conglomerate. No fossils were found in this rock. The sandstone shows mud-cracks and rill-marks, thus proving that it was formed in shallow water. The lofty peaks were islands in the primeval sea while the sandstone was formed. There are also on the eastern side of the Culebra range perpendicular walls of ferruginous sandstone. One of these walls at Beaver pond is of a brilliant red color, reminding one of the rock in the Garden of the Gods.

The Cimarron range contains a greater variety of rocks than the Culebra range. Beginning in the north with Costilla Peak, which slopes very abruptly on the northern side, we have diorite containing much olivine. Massive quartz is found on the top of Costilla Peak, and small bowlders of granite occur on its slopes. On the western side of the Cimarron range the granite assumes the columnar form, reminding one of the words of the poet:

> "The wild rocks shaped as they had turrets been,
> In mockery of man's art."

On the east side of Comanche Creek a variety of pinkish trachyte occurs in the forms of curved, long prismatic columns, resembling the basaltic columns in the island of Staffa.

Directly east of Costilla Peak is a short ridge of light-gray quartzite running parallel to the Cimarron range. The ridge is about 400 feet high. It is traversed by many fissures, and the rock is very much weathered. A small stream has cut its way through the ridge, thus forming a gap. On the west side of the ridge a bed of limonite outcrops. The rock is hard and fine grained, but breaks easily into thin fragments upon being struck with the hammer.

Proceeding south from Costilla Peak the rock is for the most part granite. Both red and gray varieties of granite occur, as well as coarse-grained granulite. On the western side of the Cimarron range feldspar-porphyry occurs, having a dark-gray matrix with white crystals. At the head of Moreno Creek the granite is poor in mica. Elizabeth Baldy Peak, the highest mountain in the Cimarron range except Costilla, is composed of fine-grained gray granite. A mass of dark-gray mica-schist outcrops on the western side of this mountain. Just north of Elizabethtown a mass of gray feldspar-porphyry outcrops. The town itself rests on granite, while blue limestone outcrops but a mile below it. In this blue limestone two species of inoceramus were found, which Dr. White informs me belong to the Cretaceous age. The occurrence of fossiliferous limestone in the Moreno Valley, between the Cimarron and Taos ranges, is in all respects singular. I was unable to define the limits of the limestone. Six miles below Elizabethtown a vein of bluish granite outcrops at the head of Cimarron River. From this point the range consists of reddish granite and granulite as far as Uraca Peak on the south. In the vicinity of Uraca Peak igneous rocks, such as trachyte and vesicular basalt, occur. Bluish hornblende schist is found on the south side of Uraca Mountain. Gray trachyte occurs along the banks of Uraca Creek, and south of this are mesas of basalt extending beyond the foot-hills into the plain. The cavities in the basalt are sometimes filled with white calcite.

The western side of the Cimarron range is much steeper than the eastern side. A series of broad foot-hills, composed of sandstone, horizontally stratified, runs along the eastern side of the range. Much erosion has taken place in these foot-hills. They are covered with a net-work of cañons. In the Van Bremmer Park there is a detached mass of yellow sandstone, about 100 feet high, standing alone in the plain and at least a mile from the nearest foot-hill. This was the most striking example of erosion noticed. Considerable lignite and a few veins of coal are found in the foot-hills east of the Cimarron range.

The Taos range consist chiefly of granite and feldspar-porphyry, but many other rocks occur also. Taos Peak, the highest point in the range, (13,143 feet high,) is composed of gray granite and syenite, capped by mica-slate. This is the only locality of mica-slate between La Veta Pass and the Santa Fé range.

A fine section of the Taos range is seen in passing through the cañon of the Colorado Creek. In entering the cañon at the Placita de San Antonio and traveling eastward

the following series of rocks were observed: Syenite, trachyte, syenite, feldspar-porphyry, quartz-porphyry, granulite, trachyte-porphyry, granite. On account of the rapid march through the cañon, I cannot give the exact limits of each zone of rock. In places the banks of the Colorado Creek contain auriferous drift, but not enough gold has been found thus far to pay for working. Just east of the head of the Colorado Creek, feldspar-porphyry occurs that has been much decomposed. The rock is soft enough at the surface to allow a trail to be made with but little difficulty, which is much used in crossing the range on the way to Elizabethtown.

Metalliferous deposits occur in the Colorado Cañon. The following particulars were furnished me by Mr. Hess:

ORE-DEPOSITS IN THE TAOS RANGE.—THE GOLCONDA MINE IN THE COLORADO CREEK CAÑON.

This mine was discovered by W. C. Hess in 1873, but no work was done until the spring of 1875. The lode runs northeast and southwest, and occurs in the main range. The country rock is granite. The lode varies from 6 to 10 feet in thickness. But two men were at work at the time of my visit. The chief ores found are those of copper and lead in the form of sulphides. The individual minerals occurring at this mine are described elsewhere in the list of minerals. The mine is owned by W. C. Hess, Charles Vernon, and Louis Noes. White men work for $2.50 a day and Mexicans for $1. There is plenty of wood and water in the vicinity. The Colorado is a swift-running stream, about 12 feet wide, and flows within a hundred yards of the lower part of the lode. A trace of gold has been found in the quartz along the banks of the Colorado Creek. There are outcroppings of ore in three places—on the lower part of the ridge near the creek, near the summit of the ridge, about half a mile south of the creek, and on the side of a gulch near the second outcrop. Game is abundant. Deer, mountain-sheep, and grouse are found. The cost of freight from Pueblo is 2 cents a pound. The owners of the mine are desirous of securing three claims of 300 feet on either side and 1,500 feet in length, making in all 600 by 4,500 feet. The owners contemplated building a blast-furnace at the time of my visit, in order to smelt the ore at the mine. The recorder of the Golconda Mine is the county clerk at Taos, N. Mex.

In passing through the Flechao Cañon, which separates the Taos and Mora ranges, yellow sandstone is seen, containing fossil leaves similar to those in the foot-hills east of the Cimarron range. The sandstone dips gently to the east. Passing over the divide, blue limestone outcrops on the side of the wagon-road running along the north side of Fernandez Creek. A zone of limestone runs north and south that contains many crinoids and brachiopods. Among the brachiopods are: *Productus semireticulatus*, *Productus costatus*, *Productus prattanianus*, *Spirifer rockymontanus*, *Spirifir* (*Martinia*) *lineatus*. According to Dr. C. A. White, these fossils belong to the carboniferous. This zone of limestone outcrops about 6 miles east of the town of Taos. Just west of the limestone yellow sandstone occurs again, beyond which is the alluvium forming the fertile plain of Taos.

The Mora range is chiefly composed of sandstone. No igneous rocks were observed within the limits of the range, excepting granite. The ridge-line of the Mora range is quite level, there being no prominent peaks as in the other ranges. No fossils were found in the parts of the Mora range examined, with the exception of a fine specimen of a fossil fern in the sandstone forming the eastern slope of Mora Mountain. This fern has not yet been determined. A few masses of eruptive gray granite occur in the eastern side of the Mora range. It is possible that the belt of carboniferous limestone observed just at the southern extremity of the Taos range runs through the Mora range. If so, it must be on the western side of it, as I failed to discover limestone on the east side.

Although the Santa Fé range was surveyed by the main party, to which I was attached, my examination of it was confined to the southern extremity. This was owing to a side trip taken to the "bad lands," in the northwestern part of New Mexico, which prevented me from accompanying the main party in their exploration of this range. From the descriptions of the topographer and previous explorers, it may be said that the predominating rock in the Santa Fé range is granite. I think the entire range consists of archæan rocks, excepting a narrow strip of blue limestone extending along the western side of the range near the base of it. This limestone outcrops within half a mile of Santa Fé, on the east of the town. The strata dip westward at an angle of about 25°, and hence underlie the town. The limestone contains well-known invertebrate fossils, such as *Productus* and *Spirifer*, similar to that found near Taos. I think there can be no doubt that the rock is of carboniferous age, and that a belt of this limestone extends northward as far as the Sangre de Cristo Pass, in Colorado. Mr. Justice, of Santa Fé, who has studied this limestone, informs me that it extends north for at least 100 miles. Although I traced the rock in very few localities, owing to the particular direction the party took in exploring the country, I am still of the opinion that the limestone at Santa Fé is identical in age with that at Taos and Trinchera Pass, on the north side of Culebra range.

The Las Vegas range was examined in the southern portions only. In crossing the range, en route from Santa Fé to Las Vegas, the valleys of the Rio Pecos, Rio La Cuera, and Rio Vaca were crossed. Each of these rivers affords a fine section of bluish limestone, containing many crinoids and brachiopods, similar to the rock at Santa Fé. I think the limestone forming the southern part of the Las Vegas range is identical in age with that of Santa Fé. The central and northern portions of the Las Vegas range contain archæan rocks, but as Dr. Oscar Loew has described this region in the annual report for 1875, reference may be made to this report for a detailed account of the geology of the range.

This chapter on the mountain-ranges may be concluded by a few general remarks on the individual ranges. The only ranges containing ore-deposits of any importance are the Taos and Cimarron ranges. In the Cimarron range both placer and vein mining are carried on, but in the Taos range there is vein-mining only.

The predominating rocks entering into the composition of the various ranges may be stated as follows: The Spanish Peaks are trachyte; the Culebra range is granite; the Cimarron range is granite and granulite; the Taos range is granite and syenite; the Mora range is sandstone; the Santa Fé range is granite; the Las Vegas range is granite and limestone.

The Culebra range contains the highest peaks; Culebra Peak, the culminating point, being 14,040 feet above the sea-level.

Cimarron range is the longest of all the ranges, being 50 miles long.

Respectfully submitted.

A. R. CONKLING.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in charge.

APPENDIX H 5.

REPORT UPON THE OPERATIONS OF A SPECIAL NATURAL-HISTORY PARTY AND MAIN FIELD-PARTY NO. 1, CALIFORNIA SECTION, FIELD-SEASON OF 1875, BEING THE RESULTS OF OBSERVATIONS UPON THE ECONOMIC BOTANY AND AGRICULTURE OF PORTIONS OF SOUTHERN CALIFORNIA, BY DR. J. T. ROTHROCK, ACTING ASSISTANT SURGEON, UNITED STATES ARMY.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEY WEST OF THE 100TH MERIDIAN,
Washington, D. C., January 19, 1876.

SIR: In compliance with your instructions of January 12, 1876, I have the honor to submit the following report of my observations in connection with the operations of the special natural history party and main field party No. 1, of the California section, field season of 1875.

The work of the season may fairly be considered as commencing at the island of Santa Cruz, off Santa Barbara coast. This island, lying south of Santa Barbara and probably distant from it about 30 miles, is nearly 17 miles long, and at its widest portion about 6 miles across. It is much narrowed near its middle by bays making in from the northern and southern coasts, and from one point to the other a wagon-road or trail exists. The island is almost wholly given up to sheep-raising. It is estimated that in the spring of 1875 there were not less than 60,000 herds of them on the island. In June 15,000 were killed for the hide and tallow alone; the offal being carted down to the shore and cast into the water, attracting immense numbers of fish to the spot.

The island is rugged in the extreme; one point is said to attain to a height of 2,500 feet above sea-level. It is from one end to the other little else than a succession of rocky hills with intervening gulches rather than valleys. In a few places agriculture to a limited extent is carried on; only enough is raised to meet the needs of the population, if indeed it does this. Here and there a level surface intervenes between the base of the hills and the ocean. What its capacity for agricultural purposes may be I am not able to say, as there is not enough water for irrigation, and as, in my opinion, the mists from the ocean would be altogether too precarious to depend upon. I am, however, bound to state that in one or two places pepper-trees had been planted and were growing vigorously without care, and that some little grain is cultivated near Prisoner's Harbor.

It appears that at the time Cabrillo made his voyage along this coast, (1542,) these islands were timbered clear to the water's edge, and we now have abundant signs of forests that have disappeared at the sea-level, where their stumps and roots still remain *in situ*. At present the indigenous forest-growth is limited to the highest summits of the island. A dense under-growth does in many places descend lower, but it never obtains to the dignity of a forest. It is simply a thicket. Among this, however, is

found one of the most beautiful and striking shrubs of the coast—*Dendromecon rigidum;* its beautiful yellow flowers shining conspicuously among a foliage that wore always a delicate glaucus bloom. It was the one redeeming feature of the vegetation.

On the grounds most visited by the herds of sheep, all vegetation, save sage-brush, *cactees* and the *erodium* or storksbill, had been entirely swept away. The grass had gone completely, and such plants of the island flora as sheep would eat, it was with difficulty that I could get even a decent botanical specimen of. In fact, pasture had become so thin that the sheep at the time of my visit mere wandering in very small bands that they might the more readily find food. Even the sage-brush was disappearing, as year after year the sheep had eaten away its leaves and younger shoots, until there was not left sufficient of the more green, succulent tissues to elaborate the sap.

It is impossible to conceive a more dreary waste than was here produced as the result of over-pasturage. The question may come up further on as to the reciprocal relations existing between vegetation and rain-fall. It would seem more than probable that ever since the discovery of the continent this and the adjacent islands had a more abundant supply of water than at present. Tradition as well as historic documents prove that in no distant past they supported a population that must have reached into the thousands. Indeed the burial-grounds, that are so numerous and so rich in articles of archæological interest, are often at points at which there is no water nearer than 3 or 4 miles, and there is abundant evidence that near the burial-places they had their permanent homes. What must have been the population that could cover, within a few centuries, an acre, to the depth of 10 or 20 feet, with the ordinary clam, muscle, and haliotus of the coast which were simply the refuse of their feasts. Yet, standing on one such shell-heap, I was able to count over twenty others within easy sight. This presupposes an immense population, and that, again, water in abundance at a point where none now exists. What has been the cause of this desiccation I am not able to say. The hypothesis has been advanced, that it is due to a greater elevation of the land. I have no evidence of this, as a fact having taken place so late as would be required; besides, it would imply also that the central portions of the island alone were changed, leaving the shore-line as it was, for the mounds and burial-places of those who formerly had water are found near their habitations, on the shore-line of to-day, a supposition which, though not impossible, is yet improbable. Supposing that a report on the results of excavations will be given, I omit any statement of them here.

It may not be out of place to call attention to the protecting influence the large sea-weeds have on shore-lines and on the harbors. Indeed to this alone, more than to anything else, is due the safety of the anchorage at Santa Barbara. It is a matter of regret that the authorities are willing to allow out-going and in-coming vessels, steamers particularly, to plough through and destroy, as they do, this the greatest protection to the harbor. I have stood on the hills to the north and west and seen the heavy swell come in from the ocean, watched it become less and less as it penetrated deeper and deeper into the "kelp" until, emerging on the shore side, its force was spent and its size gone. Instances are not wanting to show how great this protective power is. The better way it would seem would be to have certain channels through which steamers might go out and in.

From Santa Cruz Island we started to Los Angeles and temporarily joined the main party. While here I embraced the opportunity afforded by a letter of introduction from Lieutenant Wheeler to General Stoneman to visit the ranch of the latter. My time was exceedingly limited and another visit was contemplated. This I was, however, unable to make. I obtained the following facts relative to the productions of the region from General Stoneman, and they are, therefore, the result of a large and intelligent observation. In the neighborhood of Los Angeles from 40 to 60 bushels of corn (shelled) to the acre is about a fair estimate. Oats may be regarded as indigenous, and in early times the most fabulous crops of wild oats were known to grow on the soil as a volunteer crop. Frequently it was so high that it could be tied on the back of a horse. The wild oats was then the pasture of the country, and on it the thousands of "bronchos" lived without further attention from the owners. Of the oats produced under cultivation 32 pounds per bushel is regarded as the average weight. General Stoneman said that wheat could hardly be regarded as a reliable crop; it would fail, probably, four times out of five. I am led to think this is a mere local peculiarity, as certainly within 50 miles I saw abundant evidence as to the possibility of raising fine crops of this most important of all the cereals.

It would be next to impossible to overrate the number and size of the pumpkins and squashes the soil of Southern California produces. Let the reader imagine the longest field he thinks possible and he will probably fall short of truth by 50 per cent. There are thousands of persons who have from the car-windows on the Central Pacific Railroad seen the ground along the line of that road actually covered with them and of fabulous size, who will approve my statement and my failure to give figures to the incredulous. Apples are a sure crop and the trees bear in six years; peaches and plums

in four years and cherries in eight. California pears are too well known to bear more than a mere allusion here. The trees as a rule are apt to be overloaded and to break down under the superabundance of the delicious fruit they carry; hence, it is a rule with the most careful of the pear-producers to remove nearly or quite one-half the fruit to protect the tree.

The Mission grape does best, being most prolific in pounds to the acre, and yielding most wine. It is to be remembered, however, that being the longest in the country, it has this advantage as yet over the other varieties. I am, however, bound here to state, on my own responsibility, that on this fruit there are likely to be differences of opinion; some, with General Stoneman, believing the Mission grape to be the most profitable, and others the Malaga to be likely to pay best for raisins; still, differences of opinion on this subject probably indicate that both merit attention.

Coming now to the question of the growth of subtropical fruits in Southern California, there is one fact that seems hardly to have merited the attention it deserves; *i. e.*, that this capacity for growing in immediate association the vegetable products of both temperate and subtropical climates, both attaining not a usual perfection, but as a rule quite an unusual one, must of itself mark something peculiar and unique in the combination of soil and climate of the region. Nowhere else do I know of such an illustration of superabundant productiveness. It would be hard to convince one that the adobe soil one sees so devoid of vegetable life during the dry season can ever be anything else. Let him, however, see that same country after the winter-rains have awakened to new life the germs that have been scattered over the surface; no transformation of fairy scene can be more wonderful, and it is this which constitutes the proverbial glory of a California spring.

Returning from this digression, however, we will take as the type of the subtropical fruit the orange. General Stoneman estimates 70 as a fair number of trees per acre; this a rather larger number than some others plant; but as it is the result of the large experience of a gentleman well known for the reliability of his judgment, it is safe to assert that it is not an overestimate. Orange-trees grown from the seed yield a good quality of fruit, and will bear crops for the market in from seven to ten years, and in from twelve to fifteen years from the planting of the seed it is safe, with favorable seasons and a steady market, to expect from an acre devoted to orange-trees an income of $1,000 at least. I make this estimate low, to be within the limits of truth. It is not improbable that a larger yield might be anticipated. I may here add, that the longevity of orange-trees is remarkable. I have heard it asserted that trees one hundred years old produce well in other parts of the world.

Lemons, though not so extensively cultivated as oranges, do well, and promise in future to receive greater attention. They, as well as the lime, bear in six years.

Olives may be considered a regular crop. The tree is hardy, and requires less care than the orange, and it will probably pay from its sixth year on, the fruit yielding from 20 to 25 gallons of oil per tree when in its prime. I learn from various sources that it pays best to turn the olive into oil. I have never eaten finer pickled olives than those grown and cured by Mr. G. C. Welch, at Los Pueblos, near Santa Barbara.

English walnuts can hardly be considered a sub-tropical fruit. The tree is a native of the Orient, usually being assigned to Persia. It is probable that it may be considered as indigenous also in the Caucasian region, and as growing almost spontaneously as far to the south and east as India, and reaching, under cultivation, as far north as England, hence the name English walnut. It also grows in Algeria, and is cultivated successfully in Chili. Probably none of the nuts are more deservedly popular, nor do I know of another allowing so wide a range in cultivation. It is of slower growth than the trees above mentioned, and one may hardly look for anything like marketable returns before twelve years from date of planting. It becomes a beautiful tree, as ornamental as useful, is hardy, requiring little care, and has few of the enemies so destructive to some other fruits. In some parts of Southern California, when from 25 to 30 walnut-trees are planted to the acre, almond-trees, as of quicker growth and productiveness, are temporarily planted between the rows of walnuts. Citrons do well, bearing in four or five years; though one I saw, on the estate of General Stoneman, set out as a cut, bore flowers and young fruit in sixteen months.

Pomegranates require little care; have few enemies; are not injured by the frosts there; allow a large number of trees per acre, and the fruit can be kept six months. With all these qualities, it is not strange that the tree should be considered a success in the region. I may add they do well even as far inland and to the north as the old Tejon ranch.

Figs may fairly be considered a success. They begin to ripen in June, and mature crop after crop until October. The first crop, however, has too much astringency of taste to fairly represent the average product.

Almonds bear early, and for several years freely. The tree is perfectly hardy and little molested by enemies.

On General Stoneman's ranch I measured a rose-tree that was 45 inches in circumference. Near by it stood a catalpa-shoot with an astonishing history. It was the result of one year's growth, was 18 feet high and 14½ inches in circumference, and on

the top bore a crown of flowers. Here may be a proper place to allude to the giant grape-vine of Santa Barbara, which is 14 inches in diameter, and at 7 feet above the ground is divided into branches large as a man's thigh; the branches covering an area of 3,600 square feet, and its annual product is from two to three tons of grapes.

I owe much of the above information to General Stoneman, to whom I would here gratefully acknowledge my indebtedness. Before leaving the vicinity of Los Angeles I would state that the rock out-crops are mostly argillaceous, shaly sandstones, with dark-colored shales interstratified. In some places these shales and sandstones, are capped by horizontal deposits of coarse conglomerate, made up of pebbles of granite, quartz, and hornblende rock, and not firmly consolidated. This is evidently a very modern formation, though elevated at least 100 to 125 feet above the plain.

There are also numerous asphaltum springs in the vicinity, the product of which has been turned to commercial account, and promises to be more largely used in the future.

It may be best to allude here to the "Bee Ranches" of Southern California, which of late have been so productive. I am without facts to prove my belief, but there is enough evidence to make it probable that the bees derive much of the material to make the honey from plants of the buckwheat family named *Eriogonam*. Several species of the group bloom profusely in the honey-producing regions, and its analogy to the buckwheat further serves to confirm the view.

June 19, we left camp with the natural-history division for Santa Barbara. Leaving Los Angeles and going northwest, we passed many fine farms before reaching the Santa Susana range. Like all this wonderfully productive California soil, it looked unpromising, and but for the abundant evidence we had of its fertility we would have passed by as worthless. The water used for irrigating purposes is, of course, that derived from the San Francisco slope. Proximity to the ocean, however, renders much less water necessary here than in the inland valleys. About 40 miles northwest of Los Angeles we came to El Conejo Ranch. This has 49,000 acres. Wheat yields 16 bushels to the acre, (as I was informed by a resident.) Hitherto sheep-raising has been the principal interest of the ranch, and of this we had the most indubitable evidence in the appearance of the land, everywhere pastured off the very surface. How long it will take California to regain the rank pasturage the State once had is a question. Already it is overstocked, and herders are seeking feed in Arizona. It would seem as though regions like the latter, having so much land particularly adapted to the sheep-raising interest, should be sufficient ground to devote to it without devastating such portions of the country as are capable of better things.

June 22, we crossed the western end of the Santa Clara Valley, and found the farmers engaged in harvesting their barley. Much of it they simply headed, allowing the straw to remain. Large fields of good corn were seen. It was just in tassel, and gave abundant promise of a heavy crop. It is hardly overreaching the truth to say that on that day we saw thousands of acres actually overrun with wild mustard, which attained a height often of 8 or 10 feet, realizing the oriental idea that it should become large enough for the birds of the air to lodge in its branches. In some places, indeed, it might well be doubted as to whether it was a mustard or barley field we were passing, both of which were luxuriant enough; but the idea still suggested itself how much larger would either be without the other. What more than anything else surprised me in the day's march was that no attention was paid to fruit-culture. I find recorded in my notes that not a single fruit-tree was seen that day. There was no apparent reason for this. The farmers through this region (along the coast from Los Angeles to Santa Barbara) do not irrigate more than they can avoid, for the reason, as they state it, it brings the alkali to the surface. This I found to be a prevalent objection along an entire line of march during the past summer. I was much struck by the almost perpetual succession of flower-crops that the same species of plant would produce the season through. At no place was this so apparent as near Santa Barbara, which we reached on June 24.

Here my time was again thoroughly taken up by archæological work, and I was unable to devote to botany and collection of agricultural data the time I wished to, and my notes of observation lay principally along the coast by the main road from the town as far up as Los Pueblos. From the coast nothing of the surpassing richness of this strip of land is seen; the whole shore-line looks barren and univiting; once landed, however, the semi-tropical beauty of the town and its surroundings bursts upon the beholder. Pepper-trees and acacias, with their light feathery foliage, contrasting beautifully with the more stately eucalyptus and its leathery leaves. And in the gardens flowers bloom in such profusion as to utterly bewilder one unaccustomed to see such an unlimited floral wealth. Immediately out of the town, on the road above alluded to, fine groves of oaks make their appearance. They have a height, on an average, of 40 feet. With widely-spreading limbs and perfect symmetry, they are as nearly the ideal forms as it is possible to imagine. To add to their beauty, the surface is devoid of undergrowth, so commonly associated with them on the eastern continental slope.

In the main, the productions of Santa Barbara are those of Los Angeles, and it is hardly worth while to re-enumerate them here. Though it is probable wheat does bet-

ter at the former than at the latter place, or at least is a more sure crop, the farms we passed looked well, especially those of the brothers Moore, Mr. Cooper, and Colonel Hollister. The last two mentioned have been going largely into cultivation of almonds, olives, walnuts, and eucalyptus. The question as to whether these will flourish in that region as in Los Angeles is affirmatively settled. Notwithstanding all that has been said as to the vastness of the market and the impossibility of flooding it (East and West) with these semi-tropical productions, I am by no means certain that this may not occur, especially as we see each year the area devoted to such productions so rapidly increasing. Just now (January, 1876) oranges are a drug in the city markets, and this, be it remembered, is before California has to any considerable extent been adding her stock. The event in itself is a small one, yet it is not entirely devoid of significance.

The wonderful growth of the Australian blue gum in Southern California, and its direct economic value, promise for it an important mission on the Pacific coast. The wants of a vigorous civilization are rapidly using up the forest of California, and it must be remembered that the ratio of destruction will probably never be less than it is now. Hence it is almost impossible to overestimate the prospective value to California of her growing blue gums. Indeed, we of the East must not lose sight of the fact that if, as has been calculated, in less than twenty years our own apparently exhaustless pine forests will have disappeared, we may have to ask aid in timber from the eucalyptus groves of California.

I quote at second hand from Ferd. Von Mueller the following statement relative to the tree in its native land: "This tree is of extremely rapid growth, and attains a height of 400 feet, furnishing a first-class wood; ship-builders get keels of this timber 120 feet long; besides this, they use it extensively for planking and many other parts of the ship, and it is considered to be generally superior to American rock-elm. A test of strength has been made between some blue gum, English oak, and Indian teak. The blue gum carried 14 pounds more weight than the oak, and 17 pounds 4 ounces more than teak, upon the square inch. Blue-gum wood, besides for ship-building, is very extensively used by carpenters for all kinds of outdoor work, also for fence-rails, railway-sleepers, (lasting about nine years,) for shafts, spokes of drays, and a variety of other purposes." * Concerning the value of the blue gum as an antiperiodic in the various forms of remittent and intermittent fever, I think it is yet premature to offer a decided opinion. That it is of no value I could not venture to affirm. In my hands, though freely administered, it has never given satisfaction. That may be due to the circumstances that I have had to encounter, the severest and most persistent types of the disease. I do not think it in any sense a substitute for quinine, and I think the profession will yet settle down to this belief; and yet the favorable reports we have of its action must have some foundation in fact. Besides its alleged antiperiodic properties there are others to which the physicians will yield a more ready assent. I do not consider the question settled as to the presence of the trees in a malarial region acting as a preventive of "chills and fevers" and allied diseases, though I am bound to admit that the balance of evidence is in favor of their healthful influence. Such problems involve too many elements to be so speedily settled. And more than once in the history of medicine have such ideas risen, been accepted for a few years, and then forgotten. Hence the need for not only caution in generalization, but for a most careful, critical scrutiny of facts. This may lead to important results.

As worthy of attention in this connection, we may allude to the jarrah, or mahogany tree, (*Eucalyptus marginata.*) That it would thrive in California is beyond all reasonable doubt. Its chief merit being its strong, close grain and its great durability, or rather indestructibility. It is proof against all the marine enemies of ordinary wood, and hence much prized in sea-going vessels. For railroad ties it lasts a long time.

The red gum (*Eucalyptus rostrata*) is also of great economic value, on account of its durability for underground uses; lasting, when properly selected, over a dozen years for railway-ties. It has also a good reputation in ship-building.

It is a peculiarity of these Australian gums that they are soft when first cut, but become very hard when dried.

While on this question, it may be well to allude here to the idea of Mr. Stearns, that several of the acacias from Australia could also be readily cultivated on some of the drier, treeless portions of the State. Knowing the habits of the acacias generally, including the smaller ones of Arizona, I have but little hesitancy in commending his suggestion as one peculiarly worthy of a fair test.

It is impossible to overestimate the importance of these rapidly-growing gums to the Californian agriculturist. With little trouble or expense to himself, he may in a very few years have around his home a shady, health-giving grove, that will, besides

* I am indebted for this quotation and for other information to a short but valuable paper by Mr. Robert E. C. Sterns on *The Economic Value of certain Australian Forest Trees and their Cultivation in California.*

beautifying his residence, furnish him with all needed timber and fuel. In special cases, it can be made to furnish a protection to his crops and his stock from violent periodical winds. As outside the realm of exact science, but still within the sphere of legitimate speculation, it may not be amiss to inquire, too, whether enough land in some limited areas might not be gained to cultivation by planting largely the trees we have above named. It may be accepted as an axiom that the tendency of decreasing the waste, sandy areas of evaporation is, other things being equal, to increase the areas capable of cultivation. We do not know that forests actually increase the annual rain-fall, but we do know that they enable us to gain greater permanent advantage from that which is precipitated.

In Southern California, the necessity for irrigation is the rule. However, where a region lies within reach of such banks of fog as at some seasons drift in from the ocean, (and notably so at Santa Barbara,) the necessity for irrigation is much diminished.

While at Santa Barbara, we examined the asphaltum-deposit on the property of Mr. J. Wallace Moore. The point at which we saw it was between 6 and 7 miles west of the town, where there is a fine exposure of it, depending on the encroachment of the sea upon the shore bluff undermining and allowing a toppling down of the overhanging earth and asphaltum. Rising from beneath the level of the ocean to a little above it are the bituminous shales, much disturbed and inclined at a high angle.

Over them is a Post-pliocene deposit with a varying thickness of from 60 to 90 feet. The asphaltum appears to be diffused through the underlying bituminous shales, and only found in a pure condition after expressed, as it were, from the slates by pressure, and probably heat. It then rises through the crevices or less compact portions of overlying soil. In this passage it is mixed with sand and gravel, and thereby made more hard. In this condition we find it lying in masses on the shore. It appears to be entirely similar to the product of the reputed oil-wells near Ojai, which, when first leaving the ground, is soft enough to flow down a moderate incline, but which soon becomes oxidized.* Though the probability of these bituminous exudations ever furnishing enough of oil to pay for working in competition with the wells of Pennsylvania is small in the extreme, yet the asphaltum is a commercial product of no small importance. Its use for roofing houses and making pavements is well known. On the route from Santa Barbara over to the island of Santa Cruz, the Steamer Hassler (to whose gentlemanly officers we are so much indebted) passed through an "oil spring," where something like oil could be distinctly seen floating on the surface. I am unable to obtain a specimen of the substance, but it is probably intimately connected with the shore-deposit. The list of uses to which the aborigines put this asphaltum is a long one.

We found it everywhere present among the archæological treasures we exhumed at Santa Barbara. They made their rush baskets water-tight with a covering of it; pitched their canoes; made ornaments; used it as a glue to mend their broken household pottery; and, for anything I know to the contrary, employed it as a paint for the face in times of mourning, as some tribes still do. It was their panacea for everything broken that required pasting, for everything pervious that must be made impervious to water.

North of the Santa Barbara, and running nearly east and west toward Point Concepcion, are the Santa Inez Mountains. Their trend corresponds exactly with the coastline. What their influence may be in limiting the fog-bank (to which I have already alluded) to the belt of arable land between themselves and the shore, I am not prepared to say. Notwithstanding the high temperature to which the summits attain, I can hardly help thinking they act the part of condensers or limitations to the sweep of the fog, thus making its influence more positively beneficial over a smaller area. Hence the slight necessity for irrigation at Santa Barbara and in its vicinity. In places they are covered with a dense growth of scrub-oaks, *Adenostoma, Arctostaphylos,* and *Ceanothus,* constituting the densest and most soul-trying of chaparral.

The red-wood does not appear to grow south of Point Concepcion, and the Monterey cedar does not reach so far south. Along the streams which put down from the mountains to the ocean cotton-woods and button-woods are found, forming a narrow line of shade bordering the more open ground. Oaks of two or three different species form the mass of the trees from Santa Barbara back to the mountains. It may not be inappropriate to glance a moment *en passant* at the climate of the coast-line from Santa Barbara to San Diego. As our observations were simply those taken *in transitu,* I am here obliged to profit by the labors of others. I am indebted to the Santa Barbara Press for the following table of temperature at that place:

	1870–'71.	1871–'72.
Coldest day	42°	44°
Warmest day	92°	74°

* Passing down the line of flow from the Asphaltum spring, we found a living rattlesnake. It had attempted to cross, but had become fixed in the pasty mass. This may serve as a homely illustration of the consistency of the asphaltum at 100 yards from the point of exit from the ground. *Crotalus* was allowed to remain.

	1870-'71.	1871-'72.
Mean of spring	60°	60°
Mean of summer	69°	67°
Mean of autumn	65°	62°
Mean of winter	53°	53.5°
Yearly mean	60.2°	60.6°

In a series of observations extending over three years and a half we find, from the same authority, that on the coldest day the mercury stood at 42°, and on the warmest it ran up to 90°. On two occasions (due to extensive fires in the neighboring mountains) it reached 100°. This last extreme must, of course, be eliminated from any table of normal temperatures of the place.

"Comparing the hygrometer and thermometer for one year, from September, 1872, to September, 1873, we find the average difference between them for one month to be: September, 4°; October, 3.5°; November, 5.6°; December, 3.75°; January, 3°; February, 3.25°; March, 3.50°; April, 4.20°; May, 5.5°; June, 6.02°; July, 4.25°; August, 5.75°. The average difference for the year is 4.09°."

From Truman's Semi-Tropical California I obtain the elements for the following table of temperature at Los Angeles:

Month.	Sunrise.	9 a. m.	3 p. m.	9 p. m.	Monthly mean.
	°	°	°	°	°
January	40	55	64	50	52.25
February	41	56	64	48	52.25
March	40	60	69	54	55.75
April	53	66	73	57	62.25
May	56	65	71	60	63.00
June	61	70	77	64	68.00
July	66	74	80	67	74.25
August	65	75	81	69	72.50
September	61	75	85	67	72.00
October	59	74	79	62	68.50
November	49	67	69	57	60.50
December	47	57	62	51	54.25

The above observations were made by Mr. Broderick for the year 1871.

Figures from San Diego are very meager All I actually know of the climate is, its January temperature is 52°, and its July 72°. The annual rain-fall at Los Angeles is 18 inches; at Santa Barbara 15 inches; at San Diego 10 inches.

I will also extract the following from Semi-Tropical California:

"The deaths for each one thousand inhabitants in several of the leading cities of the United States are presented in the following table, and the comparison cannot fail to be suggestive:

Saint Louis	21	New York	29
San Francisco	21	New Orleans	37
Boston	24	Los Angeles	13
Chicago	24	San Diego	13
Philadelphia	25	Santa Barbara	13
Baltimore	27		

This table does not inform us whether the statistics include the host of consumptives who visit the three places last named or not. If it does these they are still, in spite of their favorable showing, charged with a percentage of mortality that is not inherent in the climate.

July 13 we broke up camp on Moore's Island and started for Fort Tejon. I would take this opportunity to state our profound obligations to the proprietors of the land on which we had been seeking for Indian antiquities, the brothers Moore; also to Mr. Joseph Park and to the Rev. Stephen Bower, the latter of whom was with us most of the time, and to whose active assistance, along with that of Mr. Park, we are so largely indebted.

According to our orders we were to have reached Fort Tejon by crossing the mountains over the trail directly from Santa Barbara. After a fair trial this was found utterly impracticable, on account of our mules being so greatly overloaded. We were then driven to take the trail via Cassitas Pass to the Ojai, and thence to the Santa Clara Valley, a little below Camulas ranch; hence left the coast at Rincon, 16 miles south of Santa Barbara. We camped for the night at a little cañon on the southern side of Cassitas Pass. The forage was poor, owing both to the presence of sheep and to the unusually dry season. There were two small but well-cultivated ranches in the cañon. The corn, though there was not much of it, looked extremely well, and the proprietor of one of the farms asserted that whatever would grow at Los Angeles could

also be raised on his farm, the altitude of which my aneroid indicated as 540 feet above the sea. The potatoes that we dug on his farm certainly were above the average, both in yield and in quality. I am prepared to believe his statement that he would get 150 bushels per acre of them. Corn yielded 75 bushels to the acre. The barley, which had just been cut, averaged 65 bushels to the acre. The gentleman boasted on the apples he raised there. Barley was sowed in January or February; corn was planted May 1, and potatoes from December to June, depending somewhat on whether they were intended for early or late use. We found the oaks, pines, and everlasting chapparal the same as at Santa Barbara.

July 17 we camped on a tributary of the Ojai and found, for the first time this season, some grass that had escaped the sheep. It stood about us over a foot high, but was so dry and tasteless that our mules would not touch it. The capacity of the soil for yielding paying-crops of the cereals was good. Indeed the environment was the most pleasing we had seen. A real lively brook, such as would have been no discredit to the Sierras, flowed over its rocky bed, worn out through the rich oak-covered plain. We found beautiful clumps of *Eriogonum*, *Adenostoma*, and, on a spray-covered rock, a handsome *Lobelia*.

Along the road from here to the dividing-line separating the Santa Clara Valley we found well tilled farms and abounding signs of a comfortable community. The divide was 1,200 feet above the sea-level, and on it we found a soil that yielded good returns of wheat, corn, and melons, with how much more besides I know not. A vigorous grove of *Eucalyptus* stood by the road-side, proving that the altitude did not interfere with its growth. We camped on the Sespo Creek at an altitude 1,025 feet.

July 20 we entered Santa Clara Valley, and as we did so passed by a large flourishing mill which was evidently doing a good business. Well-tilled farms became more common, and there seemed to be still more room and water sufficient for a much larger population. The ground reaching down from the hills was a sage-brush covered slope, while on the flats bordering the river we found a greensward, much of which was made up of sour grass, that a mule will eat rather than starve. Earlier in the season it appears there is forage of a better character to be had in the valley. The water is alkaline, but less markedly so in the river. Northeast of the valley the whitish bituminous shales are visible on the hills, and the decomposition of them contributes largely to the surface of the valley.

Camulas ranch is quite noted for the quantity of wine it produces. We found the red wine good, cheap, and with a large percentage of alcohol—quite conducive to early slumber and headache next morning. In addition to vine-growing the other interests of the region are not neglected. Altitude, 750 feet.

Following the valley up we entered by one of its arms the San Francisquito Cañon, and then the pass of the same name, crossing the summit at an altitude something over 3,500 feet. Lake Elizabeth lay from this summit almost below us. The reading of my aneroid indicated 3,170 feet as its elevation above tide-water. The lake at which we camped is one of a series of three. It is about a mile long, and shallow throughout; water trickling down to it from the hills around indicates that it is simply the result of surface-drainage. The lower lakes of the series are deeper. It is said that the waters in the lake are rising each year. I can give no positive data, however, on this point. Good crops of corn, potatoes, and barley are raised here. The whole country has been overrun by sheep, until there was not a vestige of pasture left. We were on the western edge of the desert at Lake Elizabeth.

From this place we crossed the edge of the desert to La Lievre ranch, a distance of about 25 miles. The scenery was mountainous in the extreme; here and there along the road we encountered a large yucca, that reminded us more of some similar scenes in Arizona than anything else we had seen on the trip. At this season (July) there was a bare sprinkling of the driest grass; a possible reminder that during the rainy season it would be better. Bands of sheep and a few cattle manage to eke out a slender living. Water was not passed once after leaving Mud Spring. There is usually water at one other place, but it was gone at the time of our visit. The Lievre Ranch House, however, redeems the region, for here we found quite a little stream. The water was good, but it was all evaporated or absorbed by the thirsty earth before it fairly reached the plain below. Along the edge of the desert, rocks of the Tertiary period along with some of volcanic origin are found. The former are much fractured, and are tossed in all directions. The volcanic rocks in places look almost as though stratified; they are very hard, and filled with cavities in which specimens of chalcedony are found.

From the Lievre ranch house to Mrs. Gorman's the ground is of much the same character as that just passed over; perhaps more irregular in surface, with an occasional basin in which water collects during the rainy season. Alongside the road standing water was found in several places, and on one hillside a bog indicated that a good spring could be developed by a little digging.

The Gorman ranch is the most productive in the region, at least the largest crops are raised there. Whether this is due to better work, (as is probable,) or to a better

natural locality, I am not sure. At present it supplies most of the forage used in the immediate country, furnishes the transient custom with feed for the animals, and I am told has beside a remainder for shipment to Bakersfield and Caliente.

Thence our road lay past the Castac Lake, (then a dry alkali-covered basin,) and through a valley, becoming each mile more attractive, until we reached old Fort Tejon.

It would be difficult to imagine a more fit site for a military post in this region; in a valley supplying plenty of ground fit for cultivating all the ordinary vegetables needed to maintain the health and promote the comfort of the troops stationed there; with abundance of forage for the animals in the valley and on the hills adjacent to the post; with good, cool, (62° Fahrenheit,) clear water bubbling up from several springs at the bases of the hills; with delicious shade from the ample expanse of oak foliage, and above all, in this torrid region, a constant breeze passing to and fro through the funnel-like valley at the hours that otherwise would be most unendurable.

I measured one oak tree on the now desolate parade-ground that was probably 60 feet high, and had a diameter of 8 feet 2 inches at 5 feet above the ground, with three branches each as large as a good-sized tree, carrying the shade out on all sides full 40 feet from the trunk. My aneroid barometer read 3,150 feet above the sea. The hill-sides around were, besides the oaks already alluded to, covered with a dense growth of scrub-oak, California buckeye, and a hard shrub which, for want of a more intelligible name, I will allude to as *Cexcocarpus parvifolius*. These combined form the impenetrable thicket about the post. There had been sheep everywhere to leave behind them a waste almost destitute of grass or any green herb, yet from the dead wild oats on the tops of the hills I could readily see how abundant the pasturage had once been. The water is heavily charged with carbonate of lime, which for a time induces looseness of the bowels in those using it, but ordinarily in a time becomes as healthy as it is palatable. Where the water percolates through the soil it forms considerable deposits of calcareous tufa. All the cooking-utensils in which this water was boiled speedily became coated with carbonate of lime.

From Fort Tejon the natural history party started for Cuddy's ranch, situated about 6 miles east of Mount Piños, and at an altitude of 5,150 feet above the sea. We found on the way up that the piñon pine began to be common at 4,200 feet above the sea, and extended to nearly or quite 6,000 feet, this being the most characteristic tree at these altitudes. Incidentally I will allude to the fact that while the piñon nuts of New Mexico are round and with an average diameter of three-eighths of an inch, those of California are three-fourths of an inch long and have a diameter of one-fourth of an inch; the leaves and cones, however, of the trees being to ordinary observation much alike.

East and west of Mr. Cuddy's are hills the culminating points of which are from 7,500 feet to 8,500 feet above the sea. They are made up of granite and metamorphic rocks to the summit. During the course of ages an immense quantity of detritus has been washed down from the summits, and at an altitude of about 5,000 feet above the sea has accumulated to form the flats now covered with verdure, and known as cienegas or meadows. Looking first at the rough aspect of the surrounding hills and then at these cienegas, the latter are indeed oases. I have already alluded to the fertility of the Gorman ranch. That of Mr. Cuddy though not over 2,000 feet higher, is, from his testimony, utterly unfit to raise any of the cereals except rye, which he says does fairly. He does not grow any of the garden vegetables, and hence depends entirely upon his purchases for his vegetables, the chief interest being stock-raising. He has fine bands of horses and cattle roaming at will over the hills within a dozen miles of his home.

On the part of myself and my associates there I wish to make public acknowledgment of all the assistance and kindness we received from that whole-souled gentleman.

Just here I will allude to the fact stated by Mr. Robert Prado (some 20 miles distant from Mr. Cuddy's ranch, and on the extreme headwaters of the Lockwood Creek) that June frosts killed about all the vegetables he attempted to raise. The altitude of his ranch was the same as that of Mr. Cuddy, and also about the same as the Motor ranch, where I saw a very sickly-looking field of wheat that appeared to confirm all I had heard as to the impossibility of raising any cereals amid the mountains at that altitude.

July 30.—Ascended Cuddy's Peak, southeast of Cuddy's. It was by the aneroid 7,750 feet high, and covered with a growth of bull and yellow pines to the top, along with which were growing *Eriogonum flavum* and *Artemisia tridentata*, which (the latter) is there the commonest sage-brush. Mount Piños was found also, by an aneroid reading, to be 8,500 feet above the sea. This is also known as Saw-mill Mountain. The principal timber is bull and yellow pine, which Mr. Magill is now rapidly working up into lumber for the wants of the adjoining region. He sells it at the mills at $20 per hundred feet, the yellow pine making by far the better lumber. A thermometer placed in the spring under the saw-mill read 52° F., which may be taken as not far from the mean temperature of the earth at that point. The valuable timber does not appear to grow at an altitude much lower than 6,000 feet on the side of Mount Piños. I found a peculiar-looking dwarf-oak 20 feet high at an altitude of 7,000 feet. In addition to

the pines already named I found near Mr. Prado's, on the headwaters of Lockwood Creek, some sugar-pines. They closely resembled, in their straight trunks and soft wood with long hanging cones, the white pine of the East.

August 13.—Bakersfield. This town enjoys a most unenviable notoriety for the fever and ague. Out of 17 patients in the county hospital I was informed by the attending physician 15 are victims to malaria, which here gives its own distinctive character to the pneumonia, diarrhœa, and dysentery. The cause of this prevailing disease is not far to seek. The town is situated in a low, level country, now much of it for the first time being opened up to cultivation. Much of the soil is so rich with decaying vegetable matter that it is simply a vast compost pile. During high water in June Kern River overflows its banks, and as the water recedes during the following months the vegetable matter thus left on the ground and that turned up by the plow decay and poison the atmosphere with disease-germs. Adding to this already sufficient cause, we have irrigating ditches along the streets, stagnant water in the streets, and kitchen-offal in back yards. The only wonder is that there is not more disease. Much of this, however, is rather the course of events in any new town. We may confidently look for a great improvement as the citizens bring their surroundings to their own ideas. They are energetic and know what is to be done. The place is healthier now than Illinois was twenty years ago. Among the great sanitary measures needed, none can be more important than one or two artesian wells, thus furnishing a substitute for the surface-water now used. It is extremely probable that water can readily be had in this way here.

The plants poisoning stock in this region are attracting much attention. The damage done by them to stock-raisers is immense. In one instance several hundred head of fine sheep were poisoned outright. The destruction among horses, though not so great in numbers, has probably been of an equal value in money. It is remarkable that in a family of plants the *Leguminosa*, which has until of late been regarded as possessed of so few hurtful plants, that all at once we should hear of the great damage being done over wide areas and in each location mainly by different plants of this order. In Colorado and New Mexico by *Oxytropis lamberti;* in Arizona by *Hosachia purshiana*, (so reported;) and in California by two or three species of *astragalus*. The animal becomes as addicted to its use as ever an opium-eater to his drug. It becomes a habit which we may appropriately call the *loco* habit; ("*loco*" is the Spanish for "fool.") The animal becomes demented—at one time hopelessly stupid, at another timid, and again actually dangerous. He grows progressively weaker and thinner until death comes to his relief. Sheep are more frequently poisoned by the woolly milk-weed of the region.

August 24.—We camped in the Tejon ranch. Water was so scarce that it was brought for some distance for the house, and the creek upon which a large band of Indians formerly depended for irrigating water was well-nigh dry. Along its rocky bed we saw perfect thickets of wild grape-vine, but no fruit this year. The ranch-garden was a semi-tropical wilderness; figs, grapes, pomegranates, peaches, pears, and melons, with what more I do not know, all thrive and bear profusely. We could see what the garden had been. Squirrels visit it by droves and are fast destroying the choicest trees and vines. The thermometer on August 23 stood at 110° F. in the shade at the house.

Passing by an interesting visit to the newly-opened ranch of Mr. Souther, south of Bakersfield, for the present I will simply allude to the artesian well that he now has in successful operation. It is the first one in the county, (Kern;) water was struck in quantity at a depth of 250 feet, and according to Mr. Souther's estimate the well delivers 35 gallons a minute; this I think is an underestimate. The water is good and has a temperature of 65° F., as nearly as I can guess, (my thermometer was accidentally broken the day before.) Mr. Conner informed me that Cotton ranch, near Bakersfield, was a success so far as growth of good cotton was concerned, and that the yield was fair.

August 27 found us at Walker's Basin, at an altitude of about 8,500 feet above the sea. The hills around are well covered with a growth of oaks and pines, among which (the latter) we for the first time found the Digger nut-pine. The tree may be known at once by its enormous cones, with sharp, hooked tips to the scales, over three-fourths of an inch long, and by its long leaves, which do not appear to be nearly so numerous as in the other pines of the region. Thus the tree presents a remarkably open appearance. The oaks were fairly full of acorns, and the "hog-herders" had driven their bands into the basin to take advantage of the crop. Barley grows well here, as do potatoes also, and the hardier garden vegetables, though the squirrels had destroyed almost all the fruit-trees.

Leaving the basin we crossed the divide to Havilah by wagon-road. The oak disappeared, and the forest on the hills was now made up exclusively of coniferous trees, and cottonwoods along the edges of the water-courses. After crossing another divide northward we were fairly in the plain through which the Kern River flows. There was not, except at a few spots, water enough for irrigation, and hence agriculture was limited. It is probable that during certain months the region would support a goodly number of sheep and cattle. The hot springs (though I am not aware of their hav-

ing any marked medical properties) will doubtless become important as a health resort, on account of the high temperature of the water and the proximity to interesting mountain regions. Still, even this is in the future.

Weldon is, according to my aneroid, 2,900 feet above the sea-level. Soil is sandy and alkaline, though when cultivated capable of producing good crops of corn, wheat, barley, watermelons, squashes, tomatoes, and cucumbers. Potatoes do not do so well. The most common grass on the flats just above the level of the river is the so-called sour-grass, so hard and so acid that no stock will touch it except in extreme want. It was abundantly covered with an exudation on which the sourness depends. The higher ground had a vegetation composed of *Senecio*, *Bigeloria*, and *Baccharis*, with some sage-brush intermingled. A belt of cottonwood trees skirted the river, largely supplying the fuel for the region.

September 4.—We were at La Motte's ranch; altitude was 6,700 feet. Of course this precluded, if not all hope of raising crops, at least all attempts at it. We had our first frost of the season here. The meadow (of which this is the first of a series extending quite up to the base of Mount Whitney) was fenced in, thus protecting the grass from the immense bands of sheep passing. The grass sedges and rushes making up the mass of pasturage was over a foot high—eagerly eaten by our animals as grass, but rather reluctantly taken as hay. The hills were covered with piñon pine, the altitude of this tree here nearly coinciding with that observed at Cuddy's ranch. Here, through the kindness of Mr. Kennedy, I was put in possession of some *chia*, an article well known to the Mexicans and Indians, who use it as a food on their long trips, and also mix it with water to render it (water) more palatable and refreshing, and to do away with the necessity of drinking so much. Chia is the seed of *Salvia columbariæ*. It is roasted, then ground, looking much like flaxseed meal. It is mixed with water to which a little sugar has been added, and then the whole stirred for a few minutes until a thick, mucilaginous mass is developed. The taste, which grows upon one, is at first rather pleasant. I anticipate for this an important remedial use. In inflammation of the stomach and bowels, in dysentery, and even in hemorrhoids, it has proven a remarkably soothing mixture for internal administration, combining food and demulcent medicine in one article—just one of the desiderata of the physician to-day. Besides this, I have had experience enough with it to satisfy myself of its great value as a poultice. Measures have been taken to secure enough of the seed to test its virtues more thoroughly in medical treatment.

From La Motte's we gradually ascended through meadow after meadow (all closely pastured off) until we crossed (twice) the South Fork of Kern River and camped at the foot of Mount Olanche. Here we remained some days, and I succeeded in obtaining about 100 species of plants that were in bloom. The camp was 8,200 feet above the sea, and the whole character of the timber had changed. The piñon pines were below us, and we were among the *Pinus contorta*, (twisted pines,) *Pinus ponderosa*, and spruces. I could see that they extended well up toward the summit of the Olanche. Sage-brush covered the valley on which we camped. Higher up I found many beautiful compositæ and a splendid lupine in full bloom. The timber is of considerable value, but so remote from market that it is not likely to be utilized for many years. At 10,500 feet I found a cedar 4 feet thick growing vigorously. It was not more than 40 feet high, however. At 10,000 feet I observed a peculiar-looking pine, which I take to be *Pinus deflexa*, Torr. Having only insufficient specimens and no authentic herbarium specimen, I am unable to speak with certainty on this point.

From this camp, until we reached the base of Mount Whitney, there was no noteworthy change in the flora. There, however, we encountered, in addition to the coniferous trees already alluded to, *Pinus albicaulus* and *Pinus Breweri*, (what, at least, I take to be the latter species provisionally so named.) Observation on a peak south of Mount Whitney gave 12,100 feet as the height of timber-line. The dead and dying trees at what is now timber-line were a puzzle to us. What can have caused this I do not know. A halt of two days was made at a point midway between Mount Whitney and the Soda Springs, on the North Fork of Kern River, to await a portion of the party. Here Mr. Klett made the ascent of Meadow Mountain. I am indebted to Mr. Klett for the observation on timber-line. On the north side of the mountain it is 11,200 feet, and on the southern side 12,000 feet above the sea. Soda Spring, on the North Fork, was our next camp, and here we remained several days. The forest-growth at once assumed nobler proportions. One fallen *Pinus ponderosa* was measured, as it lay upon the ground, and found to be 160 feet high. It was 6 feet through at the base, and was straight as an arrow. *Librocednes decunens* was also quite common. Both of these trees must yet be made available as lumber. The size and quality of such trees will make them sought for at almost any cost ere long. We found here good pasturage for our animals. It was, however, almost entirely sedges and rushes, with but little genuine grass among it. Higher up on the mountains, where the sheep had not been, a still finer quality was found. The water is remarkable for the quantity of iron it contains. There is also enough carbonic acid escaping to make it pleasantly pungent; besides, it is decidedly alkaline in taste; it has not (that I could discover) any lax-

ative properties. That the water will be proven to have an alterative effect I have no doubt; and that the iron will confer upon it a tonic effect I am equally sure. With such a combination of properties and situated in a perfect center of mountain scenery, with a fine climate and good fishing superadded, it will be among the marvels of the world if this spot does not in time become a most popular resort. We saw here the first oak we had seen since leaving Walker's Basin. It was a mere shrub, never exceeding 10 feet high. The mountain-sides had a thick chaparral of *Ceanothus* and *Castanopsis*.

Back of the Soda Springs, at an elevation of 10,000 feet, I came upon a deep wash in the side of the mountain. It was over a mile long and literally strewn with tree-trunks that had been washed (probably by melting snow or a water-spout) from the steep hill-sides. Below, this gulch terminated in a flat bog. In this bog were found layer upon layer of logs that at one time or another had been swept into it. Over all and among all was the wet mud—the mass being transformed into, may be, a peat-bog or, may be, a mere marsh. Still, the case was so striking and so like some of the events of former geological times that I could not avoid making a note of it.

Going south from Soda Springs we crossed on the old Visalia trail a western fork of the North Fork of Kern River, which was half as large as the main stream. It ran through a valley deeply scored and furrowed by glacial action. South of this, crossing a divide, we came upon the headwaters of Tule River. Dense forests of spruce covered the higher ridges, and in the valleys between were open meadows that, but for the sheep, would have been well covered with long grass.

Sequoia gigantea, the giant of our New World forests, grows, at a mean altitude of something over 6,000 feet, quite abundantly on these tributaries, as well as on those of the North Fork of Kern River to the east. They are fully as large as the more noted ones so frequently the wonder of tourists in the Calaveras grove. Here they are seen along the hill-sides in association with the other usual coniferous growth. It is rare to find one of the larger specimens unhurt at the base by fire, or with a top that is not in some way injured. I was struck with the apparent scarcity of young trees of this species. It is not an unusual thing to find these trees with a diameter of thirty or thirty-five feet, and attaining a height of two hundred and fifty feet. We found the "sugar-pine" (*Pinus Lambertiana*) on one occasion growing on the head of Tule River, at a little over 7,000 feet of altitude. This, to my mind, is the most graceful of all our western conifers, as is its relative, the white pine, the most comely of our eastern pines.

It is usually straight as an arrow, with a clean trunk towering to 200 or more feet high, and a diameter of from 5 to 10 feet. From the ends of the branches the cones, a foot or more long, hang straight down in beautiful clusters of two or three. Its range in altitude is from 3,000 to 7,000 feet, attaining probably its finest proportions at from 4,000 to 6,000 feet. The resin, especially in trees that have been injured by fire, is markedly sweet, hence the name of "sugar-pine." The timber is of great value, being soft, light, and free from knots.

After crossing into the valley of Deer Creek there was another change in the arborescent vegetation. The pines were on longer the characteristic feature of the landscape. Oaks supplanted them, and among these *Quercus lobata*, resembling the white oak of the East, was most common. It is remarkable for the great length of its acorns, and furnishes good fuel. Though by no means equal to our eastern white oak as an article of lumber, it is not without its uses. In the valley we found fine crops of corn, wheat, and barley. Potatoes were especially fine, being large, sound, and boiling into a delicious "mealiness." I measured one potato-vine and found it to be eleven feet long.

Linus Valley we found to be in its flora much the same as that of Deer Creek. It was larger, more thickly settled, and supported large herds, but none of the cereals are raised there. Even barley, I am told, is brought in from Kern River, and there is not a thrashing-machine in the valley. This appears unaccountable. There was a grist-mill there at one time, and the soil is capable of raising almost anything.

From Linus Valley we crossed to the valley of Kern River, passing on our way a saw-mill that supplies from the well-timbered slope all the lumber needed in and about Kernville.

From the last-named point to Caliente our route lay through the region already gone over. It was noticed that though we had had but a few showers the hill-sides near Caliente were becoming quite green, as those of Walker's Basin, fourteen miles away, were indicating the approach of winter.

I have the honor to be, very respectfully, your obedient servant,

J. T. ROTHROCK,
Acting Assistant Surgeon, U. S. A.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in charge.

APPENDIX H 6.

REPORT ON THE PHYSICAL AND AGRICULTURAL FEATURES OF SOUTHERN CALIFORNIA, AND ESPECIALLY OF THE MOHAVE DESERT.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN.
Washington, D. C., April 7, 1876.

DEAR SIR: I have the honor to submit herewith a report upon the physical and agricultural features of Southern California. It treats of the coast counties, of the island of Santa Cruz, and of the Mohave Desert, with the valleys, oases, and soils.

Respectfully, your obedient servant,

OSCAR LOEW.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in charge.

California is pre-eminently the land of great contrasts. From the living glaciers of Mount Shasta down to the coast of the grand Pacific exists every variety of climate. There the snow-capped peaks, here regions where snow-fall is unknown. From the bald peaks beyond the growth of trees are passed, in descending the mountain-slopes, dense forests of pine, with beautiful, charming scenery; next below, in altitudes from 5,000 to 6,400 feet, follows a belt of trees of 30 feet and more in diameter, of from 280 to 320 feet in height, and reaching an age of three to four thousand years; then succeed the fine agricultural valleys of the Sacramento, of San José, San Joaquin, Napa, Sonoma, and Tulare, and lastly the sea-coast region.

Ascending the gradually-rising western slopes of the Sierra and glancing at the other side of the picture, what a contrast is offered by nature to view! Beyond the precipitous eastern slopes a country spreads destitute in the extreme, and instead of the game regions of the Sierra is seen a region in which the jack-rabbit is nearly if not quite the only game. From here toward the south, passing the eastern slopes of the Sierra, the Owens Lake and the Panamint Valley to the Coahuila Valley, one finds for a distance of 300 miles a dry country, where springs are scarce, and in some cases of saline and bitter taste, where the hill-chains exhibit the plain rock, and the valleys are made up of coarse sand with scanty vegetation, or in not few instances of naked clay, resembling a barn-floor.

Now from the Coahuila Valley to the westward, crossing the San Bernardino and San Jacinto Mountains, the flourishing oases of San Bernardino and Los Angeles are entered. Here are grown—with artificial irrigation—the orange, the almond, the fig, the castor-bean, mulberry, olive, lemon, the pepper-tree, the palm, and the grape-vine. Three millions of oranges are annually produced at Los Angeles, while the wine-production of that county is estimated at 1,000,000 gallons. As there is an overproduction of wine, considerable quantities of grapes are exported as raisins, or serve for manufacture of syrup and grape-sugar. Again, what a strange contrast those tropical gardens present with the barren hills of the vicinity of Los Angeles! Nature here takes her vacation in summer-time, the vegetation sleeps, the grass dries up and disappears, and only when assisted by art she develops her tropical powers. In winter, however—if a warm season with frequent showers can thus be denominated—the hills and valleys of the coast counties become covered with rapidly-developing verdure.

The peculiarity of the California climate exercises considerable influence on agricultural pursuits, and demands a mode of farming different from that of Europe and the east of America. Plowing is not possible during the summer, dryness baking the earth, and the farmer has to wait until the rainy season has set in and softened the soil. The prolonged dryness of the summer-season is not favorable to the cultivation of Indian corn, (without irrigation,) hence such cereals as soonest mature form the principal object. Wheat stands foremost in the California farming, then follows barley. Of less importance are corn, rye, oats, and buckwheat. Tobacco, potatoes, sweet-potatoes, tomatoes, sugar-cane, hemp, flax-seed, mustard, hops, castor-beans, cotton, and fruit-trees are also cultivated to a moderate extent.

The middle and northern counties are the principal wheat-producing regions, while the southern ones, depending exclusively on irrigation, raise comparatively more corn and less wheat.

Another peculiarity produced by the climate is seen in connection with the production of grasses, whose propagation depends solely upon the annual germination of seed, and not, as elsewhere, principally upon the spreading of the roots.

In California the roots dry up during the prolonged rainless season, and thus lose their vital power. Here meadows similar in character to those of the East are unknown, whose turf is an overproduction of living grass-roots. The grass crumbles,

stem and seed fall to the ground; and while the uninformed eye of the stranger looks in vain for the grass, cattle and sheep still find subsistence on the apparently barren soil. But as the production of hay is naturally limited, a substitute was introduced, namely, the perennial alfalfa or the Chilean clover, (*Medicago sativa*,) which allows repeated cutting in summer. Its roots penetrate much deeper into the soil than those of the ordinary grasses, and hence survive a drought much easier; it is in this respect, of course, much preferable in counties with dry climates. However, nobody will deny that alfalfa is inferior to our eastern clover, the proportion of woody fiber being much larger. Also wheat and barley-straw, (unthrashed,) called "hay" in California, is used as a substitute for the natural grasses. While a great production must readily be conceded, especially to Middle and Northern California, the drawbacks cannot be underrated at the same time, of which, for instance, the great number and destructive habits of the gopher (*Spermophilus Beecheyi*) is not a small one, undermining the field and gnawing off the roots of the cereals.

A considerable share of wheat and barley is raised in volunteer* crops, but it is a poor method, and only the lazy farmer's way. As irrigation—especially in the southern half of the State—is an imperative necessity, consequently good farming country is not cheap, and all the lands which are supposed to be suitable for production of grain have passed out of the control of the Government, and large tracts are held by a few private persons. However, there is prospect that these lands will finally be subdivided, and thus the existence of a denser population made possible.

Near Santa Barbara and Los Angeles an acre of good land is worth $150 to $200; in the vicinity of San Bernardino not less than $100, and this in face of the fact that sometimes in dry years the crops are a failure, the creeks for irrigation running dry. Artesian wells, it is true, are sunk easily at San Bernardino; there are over 100 with a depth rarely exceeding 140 feet, but they are not practicable on the higher country 10 miles from town. The fine oasis of San Bernardino is one of the few spots of San Bernardino County that are valuable, the larger part of it belonging to the Mohave Desert.

As might naturally be expected, the settlements in Southern California are not large, facilities for irrigation being limited.

Another noticeable fact is the absence of forest on the Coast ranges, which to an altitude of 3,000 feet are mainly covered with brush. Neither exist forests of any material extent upon the islands of the Santa Barbara Channel; upon one of them—the island of Santa Cruz—Dr. Rothrock, Mr. Henshaw, and myself passed nearly a week.†

THE ISLAND OF SANTA CRUZ.

This island covers 73.4 square miles and is of mountainous character; the highest peak is Devil's Peak, with an altitude of 2,700 feet. Anacapa and Santa Rosa Islands are seen in immediate vicinity. While the islands San Clemente, San Nicolas, San Miguel, Anacapa, and Santa Barbara belong to the United States, Santa Cruz, Santa Rosa, and Santa Catalina are private property All the islands of the Santa Barbara Channel were discovered in 1542, by Juan Rodriguez Cabrillo, who was sent out by the Spanish governor of Mexico on exploring voyages.

The names first given to these islands were repeatedly changed, making it difficult to follow the later Spanish writers. Cabrillo died while on one of the islands—probably Santa Cruz—and was buried there. Besides the islands mentioned, Cabrillo pretended to have discovered six others southwest of San Clemente, which, however, never were seen by subsequent explorers. Whether those six islands really existed and sank afterward below the waves of the ocean, or whether they were an ambitious invention, cannot be decided. The reporter of Cabrillo's voyage says: "El 18 Febero, 1543, conviento N. E. corriéron al SO (de la isla San Salvador) en busca de otras islas que habia; viéron seis, unas grandes, otras pequeñas, y sin tocar en ellas siguiéron al SO." To this a Spanish historian‡ of the last century makes the following remark: "No se puede saber quales sean estas islas, que vió Cabrillo, pues al rumbo SO de la isla San Salvador ó San Clemente no las hay ni se tiene noticias de éllas." (On the 18th of February, with northeast wind, they sailed in southwesterly direction from the island San Salvador in search for other islands, which indeed existed; they saw six, one large and others small, and without touching them continued to the southwest.)

Remark of the historian: "The islands Cabrillo saw are unknown; for there are none in existence southwest of the island San Salvador or San Clemente, nor do we have any notice of such."

The islands are chiefly of volcanic origin, while at Santa Cruz the heights consist of trachyte and trachydolerite; the valleys are covered with Quaternary deposits of clays, sands, and conglomerate. Where the latter form the coast-rock it succumbs

* The local expression for spontaneous.

† Thanks are due to Lieut. Commander H. C. Taylor, of the Coast-Survey steamer Hassler, who kindly conveyed us from the coast to the island and return.

‡ Relacion de la viaje por las galetas.

gradually to the power of the waves. There exist unmistakable signs of the island having been subjected to repeated changes of level.

The vegetation of Santa Cruz is scanty; grass is gradually disappearing before the clean sweep made by the sheep-herds, whilst cactus, especially *Opuntia*, is spreading more and more. The mountain-sides are here and there covered by small patches of pine, while the low brush attempts in vain to conceal the barren rock, prominent in all the hills. It is said that formerly the entire island was covered with forests; whether true or not, one fact was observed by us, namely, that roots of pine trees exist in the loose soil of the western shore, where no trees in wide circumference occur at present.

Like the vegetable, the animal life is restricted to comparatively few species. Wild hogs are said to roam in great numbers, the progeny of those introduced by Sebastian Viscaino, (1606.) Wild cattle are also said to occur. The most interesting animal, however, is a fox, (*Vulpes littoralis*, Baird,) not larger than a house-cat, and found solely on the three islands of Santa Cruz, Santa Rosa, and San Miguel. It agrees in almost every particular, except in size, with the twice-as-large *Vulpes Virginianus* of the mainland. The principal food of this small fox consists of grasshoppers, as Mr. Henshaw ascertained by dissection. There can be hardly a doubt that this animal was gradually produced by the diminishing of the size of the common fox, which searched on that island in vain for a more substantial food than grasshoppers, nothing else being attainable; and thus furnishing an argument in support of the theory of transmutation of species by isolation, recently advanced by Moritz Wagner.* Truly there are sea-birds whose eggs would be welcomed by this fox, but these birds are too cunning not to pick out the most secure spot for their young. The sheep existing on the island, introduced but very recently, are large enough to resist attack.

However, there exist a number of other species of animal life isolated upon these islands, as pointed out to me by Mr. Dall, engaged as naturalist for a number of years upon the Pacific coast. On the Santa Barbara Island is found a species of snail, (*Binneya notabilis*,) not found upon any of the other islands, (not on Santa Catalina, as stated in one publication.) Another snail (*Helix facta*) is peculiar to three islands, viz, Santa Barbara, San Nicolas, and Santa Catalina. *Helix Gabbii* is only encountered on San Clemente and Santa Catalina, while *Helix Tryoni* is limited to Santa Barbara and San Nicolas Islands. None of these snails occur on the mainland.

While these facts can only be satisfactorily explained by a gradual transmutation of species by isolation upon the islands, where the struggle for existence was diminished and the enemies were few, we have a case of a somewhat different kind in a small green crab, *chlorodius*, inhabiting shallow sea-banks near the coast, which, on several points west of the town of Santa Barbara, has migrated into the swampy flats, separated now by deposits of sand from the ocean, and accustomed itself to live out of the water the most of the time, under which circumstances some changes have begun, especially noticeable with the shears and legs, which have attained a stronger development in consequence of their employment in digging holes, which art the animal has acquired.

Forty years ago Santa Cruz came into possession of several Californians who established a sheep-ranch on it, and brought the last remnant of the aborigines across to the mainland, where they scattered and disappeared among the multitude. The graves and kitchen middings left behind on the island were the subject of examination by Paul Shoemaker, employed by the Smithsonian Institution, while some of those upon the mainland were discovered by Dr. Yarrow, Dr. Rothrock, and Mr. Henshaw, of your survey, and the rich treasures conveyed to Washington.

During the stay on the island the mornings were foggy, with southwest winds, while the northwesterly breeze of the afternoons brought clear weather. The peculiar changes in the height of the tides are a subject of great interest, one of the two high tides being much the higher in twenty-four hours. A full account of this peculiarity is found in the report of the Superintendent of the Coast Survey, 1853. The "southern swell" is another fact important for navigation in those regions.

THE MOHAVE DESERT.

In former times the whole country between the Missouri River and California was termed the "Great American Desert." As population spread toward the West, seeking new homesteads, it was discovered that immense areas of that so-called desert were fine arable land, notwithstanding the absence of trees. What immense tracts of Nebraska, Dakota, and Eastern Colorado have since been reclaimed! The opinion gained ground of the non-existence of a desert upon this continent; the assertions that there exist true deserts were and are still ridiculed in books and newspapers. But such is the fact: there are tracts in Nevada, California, and Arizona that rival the Great Sahara in every particular, except in the number of square miles. The naked

* Mr. Ridgeway has described recently eight new species of birds from the island of Guadaloupe, 200 miles southwest of San Diego, which may be cited as another argument in favor of this theory.

hills, the barren, stony plains, the sand-storms, the cloud-bursts, the intense heat, the daily great contrasts in temperature, the dryness of the air, the singular forms of the scanty vegetation, the bitter and salty waters, the saline efflorescences, the mirages, the dried-up lakes, all prove the existence of a true desert.

Three subdivisions of the former so called "Great American Desert" may be made:

First. The *treeless, grass-covered plains* (llanos) of Nebraska, Dakota, Western Kansas, Eastern Colorado.

Second. Semi-deserts. Trees are absent and grass is scanty below altitudes of 4,500 feet, but low brush is plentiful, as atriplex, (grease-wood,) artemisia, (sage-brush,) aplopappus, ephedra, yucca, cactus. In this category belong Northwestern Texas, (*llanos estacados*, or staked plains,) Western Indian Territory, and those portions of New Mexico, Nevada, Utah, and Wyoming that have less than 4,500 feet altitude. As these latter Territories are traversed by many mountain-ranges and plateaus of considerable altitude, (from 5,000 to 9,000 feet,) extensive oases are formed, with fine grass, many streams, and dense pine forests, permitting numerous settlements. The traveler cannot sufficiently admire the great contrast between the beautiful vegetation of the forest-covered mountains and the arid plains at their feet. The fact is that the small amount of rain visiting those Territories is principally deposited upon the mountains, which, being cooler than the valley, nearer to the clouds, and attracting them by gravitation, receive the precipitates. Furthermore, the relative humidity of the mountain-air is higher, the average temperature being lower; hence the splendid development of vegetation finds a simple explanation.

Third. True deserts. The rain-fall is so limited that the vegetation sinks to a minimum, and disappears in some instances altogether. To this class belong the Painted Desert in Northeastern Arizona and Southern Utah, the Gila Desert in Southwestern Arizona, and the Mohave Desert, comprising Southeastern California and the southwestern corner of Nevada. Lower California, although a portion of Mexico, belongs geographically to the Mohave Desert. Said three deserts would form one coherent great tract if the plateau of Central Arizona, of an average altitude of about 7,000 feet, and extending from the Sierra Blanca, in Southeastern Arizona, to the Cerbat range in the northwestern portion, and comprising the Pinaleño and Pinal Monntains, the Mogollon Mesa, the San Francisco Forest, and Bill Williams's Mountain, did not intervene, forming a part of the Colorado Plateau, and representing a splendid great oasis, with immense forests, luxuriant meadows, and numerous springs and mountain-streams. It is difficult for the imagination to conceive any greater contrast than that existing between the Mogollon Mesa and Death Valley.

The Mohave Desert is by no means a vast plain with loose sand, or a system of sand-dunes and rocks, but forms an almost uninterrupted series of hill-chains, valleys, and mountain-ranges. The latter increase in height the farther north they are situated, the Inyo and Panamint ranges reaching 9,000 to 10,000 feet altitude, while the Providence, Opal, Payute, and Dead Mountains, of the central portion of the desert, reach 5,000 to 6,000, and the Chocolate, Chucavalla, and Riverside Mountains, of the southern portion, average hardly 4,000 feet.

In regard to the intervening valleys, a marked distinction between deep and shallow basins becomes manifest. Death, Salinas, Owen's, Panamint, Ivanpah, and Coahuila Valleys are examples of the former, representing deep depressions, while the more common form is that of a plain, gradually ascending toward the mountain-slopes.

Next to the mountains and valleys the oases come into consideration. There is, however, only one of great importance, the valley of the Colorado River, after which follow the valleys of the Mohave and Virgen Rivers. Besides these, smaller oases, covering a few acres and caused by a spring, occur, although in limited number. Los Toros, Dos Palmas, Hundred Palms, Whitewater, and Agua Caliente, all in the Coahuila Valley; Bitter Springs, 20 miles north of Callville; Indian Wells, Granite Wells, Coyotehole, Little Lake, may be mentioned. Next to these, the higher mountain-ranges may be said to change into oasis-like regions above an altitude of 5,000 feet, verdure becoming plentiful, springs are met, and game (mountain sheep and deer) easily find existence.

The Opal Mountains, with Trance Spring, and Ivanpah, the Payute, and Providence Mountains, with the mining district New York, the Cerbat range, with Mountain and Quail Springs, deserve here especial mention.

The altitude in which the oasis region begins increases toward the north, and the Inyo range, although reaching nearly 10,000 feet in height, gives an example of an unparalleled scarcity of water, comparing in its vegetation unfavorably with the mountains farther south. In these northern portions of the Mohave Desert are situated the Salinas and the dreaded Death Valley, the latter 130 miles long, 15 to 40 miles wide, and in part 200 feet below the sea-level. The Telescope and Panamint ranges separate it from the Panamint Valley, a hot and deep basin, with a soil of barren clay in the central portion and of gravel in the peripheral parts.

It is a singular and favorable coincidence that in both Death and Panamint Valleys, where no springs are fed by rains, hot waters issue from the bowels of the earth, thus

supplying what meteorological conditions refuse. The neighboring Owens Valley, bordered by the Sierra Nevada on the west, by the Inyo range on the east, represents an oasis, with the two settlements Lone Pine and Independence. It is traversed by the Owens River, one of the few streams originating upon the eastern and precipitous slopes of the Sierra Nevada.

Some distance south of Panamint and Death Valley the Ivanpah Valley is situated. This is a deep depression between the Payute and Opal range, from which it receives the drainage. It exhibits in an excellent measure the elutriating influence of the water, for, from the coarsest gravel along the base of the mountains to the fine clay in the middle of the valley, a full series of transitions is met with, affording a large belt of good soil for agricultural pursuits, if water for irrigation could be obtained by artesian wells. A fair test in this direction should be made, as the mountains on either side are of considerable height, and receive in summer-time a moderate amount of aqueous precipitates.

East of the Ivanpah Valley, between the Payute Range and Dead Mountain, extends a shallow, plain-like valley of much higher altitude (3,500 feet) than the former, (2,700,) with gravelly surface.

The next great basin east from there is the valley of the Lower Virgen, with an average altitude of 1,300 feet, and groves of mesquite trees fringing the river margins. The river is but small; its waters contain a reddish mud in suspension, and sulphates of soda, lime, and magnesia in solution, to such extent that the taste forbids its use; hence the absence of settlements. For further particulars the reader is referred to the chapter on the "analysis of mineral springs and saline waters."

South of this valley, in the northeastern corner of Arizona, extends the great "Detrital Valley," or the "Forty-mile Desert," from the Colorado River to the foot of the Cerbat range, bordered on the west by the Blue Ridge Mountains, and covering an area of about 1,200 square miles. Bleached bones of horses and cattle, graves of perished persons, tell of the dangers of that stretch; dangers much greater in proceeding toward the river than in the opposite direction when passing toward the far mountains; in the latter case higher and cooler regions are before the weary traveler; in the former, he is descending gradually to the hot and deep Colorado Valley, the fatigue and thirst thus increasing enormously, and death overcoming in not few instances those who have approached to within a few miles of the longed-for river. The greater portion of the "Forty-mile Desert" is of gravelly surface, strewn over with bowlders. The scanty vegetation is formed by *Larrea Mexicana*, *Yucca brevifolia*, *Echinocactus cylindraceus*, and *Atriplex.* Along the base of the Cerbat range, however, in altitudes of 3,600 feet, good bunch-grass makes its appearance, and a few hundred feet higher up the excellent mesquite grass, (*Bouteloua sesleria*,) *Holocantha acacia. Tuniperus* contribute to improve the floral aspect.

The two important springs on the northern slope of the range are Mountain Springs, issuing from basaltic rocks, and 10 miles farther west, Quail Springs, from granite. At the latter a family recently settled, supporting themselves by stock-raising and by selling the water of their improved spring to travelers and teamsters. Twelve miles southwest of Quail Springs, in the foot-hills, is situated the now-abandoned mining settlement Chloride, consisting of about thirty adobe buildings. It was founded in 1870, and inhabited only for five years, when the yield of the mines diminished. Four miles southwest from this place is the now-flourishing mining settlement Mineral Park, a designation that certainly is not derived from a park-like condition of the surroundings.

The most eastern portion of the Mohave Desert comprises the northern part of Los Angeles County and the southern part of Kern County, and is traversed by a branch of the Southern Pacific Railroad. For great distances the only relieving sight in the sand-waste are isolated specimens of *Yucca brevifolia*, a plant that, singularly enough, has caused the name "Palm Plain." What a sweet deception for the unprejudiced who looks here for palms!

The largest valley in the southern portion of the Mohave Desert is the Coahuila Valley, being 90 miles long, 10 to 30 miles wide, and in part below the level of the sea. Beginning with the San Gorgonio Pass, it separates the San Bernardino from the Jacinto Mountains, and widens out toward the dry-lake bottom in its southern portion, where it is joined by the so-called "Colorado Desert," the low, hilly, barren stretch connecting this valley with the mouth of the Colorado River. Whilst the mountains near San Bernardino are clad with extensive pine forests and the lower Jacinto Mountains with a good deal of piñon, the Coahuila Valley presents a most desolating sight; its northern portions consist of a system of sand-dunes and sand-hills, whose formations are caused by the wind heaping the sand around every object higher than the soil—a bush, for instance, as the stunted acacia—while its southern portions of bare clay are covered with patches of saline efflorescences.

Fortunately there are a number of oases to relieve the monotony; the large ones, Toros and Martinez's, covering several square miles. At Toros, situated at the foot of the steep eastern slopes of the Jacinto Mountains, water is reached at a depth of 3

feet; grass is plentiful, and cattle roaming between the little groves of mesquite produce a most refreshing sight after the long march through the deep sand. At Martinez corn is raised with success, while our surprise reaches its maximum by the sight of palm trees (*Brahea*) in the little oasis Dos Palmas. I think it not improbable that artesian wells ould be bored with success, and large tracts of the barren sand converted into productive fields, north of the clay flat above mentioned. Between the Coahuila Valley and the Lower Colorado extends the broad divide of Chukavalla, with an elevation of 2,500 feet. Nowhere in the desert have I seen the dry-washes covered with such well-developed vegetation as here, and it appears almost like a contradiction of nature when we see them side by side with the stony plain, whose scanty vegetation mainly consists of isolated specimens of *Larrea Mexicana, Fouquieria splendens,* and *Opuntia ramosissima.* Looking at the spendid acacia trees of the dry-washes, one easily forms the opinion that water must be struck at a moderate depth; but, alas, attempts have failed to confirm this supposition, and in one case (at Mule well) water was found at a depth of not less than 80 feet. A large spring issues at the western foot of Chukavalla Peak, and here an individual has squatted who ekes out a livelihood by keeping the spring in good condition and selling the water to the travelers. The grass found in the neighborhood of the peak is gathered and sold to teamsters and emigrants. This man communicated a fact worth recording. He states that there lives in the grass a peculiar insect called *campo mocho* by the Mexicans, (the insufficient description given points toward a *Phasmida,*) which being of a green color, and therefore not being distinguished by domestic animals, and eaten, produces death in less than twelve hours. As no occasion was offered to collect it, attention of traveling naturalists is here called to the fact for investigation.

From Chukavalla Peak northward to the Mohave River extend a series of low mountain ranges and shallow valleys, almost destitute of vegetation and water. It is a dangerous undertaking to cross this stretch in summer-time, and several parties who attempted to pass from San Bernardino in a direct easterly line to the Colorado have never been heard from. Two years ago an enterprising man, intending to establish a short road to Arizona from that town, succeeded in crossing with a wagon provided with sufficient water for himself and animals.

BOTTOM-LANDS OF THE LOWER COLORADO.

The Colorado River may justly be termed one of the most remarkable rivers of the world. Where else exists a stream that cuts its way from 3,000 to 6,000 feet deep through solid rock? Where else such a vast system of gigantic cañons, impressing the beholder with admiration and awe?

Great as appears the scientific interest attaching itself to this river, the value for agricultural purposes is small compared with the immense stretch of country it traverses. After its formation by the Green and Grand Rivers, it enters the far-famed Great Cañon, 280 miles in length; then, after a stretch of 48 miles, the Bowlder Cañon, 20 miles long and 500 to 2,000 feet deep. Leaving this cañon at the ruins of the Mormon town, (Callville,) it traverses but for a short distance an open country and enters the Black Cañon, about of the same dimensions as the former. The next cañons are those of the Needles, 90 miles farther south; one at Mount Whipple; and another between Ehrenberg and Fort Yuma.

From the mouth of the Great Cañon down to Fort Mohave the sole bottom-land is Cottonwood Island and vicinity, the banks of the river being generally very high and the country rocky. This island, 6 miles long and about one-quarter mile wide, is the abode of a number of Payute families. A small farming settlement could find a flourishing existence here, where probably over several hundred acres of good alluvial soil are covered with mesquite, cottonwood, and grass. Farther down the river is situated the now-abandoned settlement Hardyville, 5 miles north of Fort Mohave, and here the bottom-lands gradually begin to expand and form a most valuable oasis. The river branches out here and there, forms lagoons, and spreads its waters through the soil. The fine corn-fields of the Indians and the groves of mesquite bestow an aspect on the valley which is the more pleasing in the contrast it affords to the destitution of the adjoining country. The wide valley, whose present inhabitants are three white settlers and several hundred Mohave Indians, commences at Fort Mohave, extends 25 miles to the southward, and terminates at the Needles, a portion of the Mohave range, through which the river has washed a cañon. South of that range exist several other large valleys, well suited for subtropical farming, and reaching in places a width of 10 to 15 miles. The shifting of the river-bed, it is true, is a great drawback—the settlement and military camp (La Paz) had to be abandoned on that account; but engineering skill could probably remedy this. A portion of that region is at present an Indian reservation; but the extent of the bottom-lands are great enough, especially south of the Riverside Mountains, to support thousands of settlers. The climate, although very hot during four months, (June to September,) presents no serious drawback, as the inhabitants of the small town of Ehrenberg can testify. The soil is rich in the chemical combinations required for fertility, and only in small patches rather

impervious, containing too large a proportion of clay. In some places, also, it contains small quantities of chloride of sodium and sulphate of lime. A specimen of a somewhat clayey soil, 6 miles east of Ehrenberg, was analyzed, with the following result:

Mechanical condition:

Silt	52.30
Clay	34.20
Hydroscopic water	3.65
Chemically-bound water	8.91
	99.06

Chemical constituents:

Insoluble in hydrochloric acid.	Potassa	0.283
	Chloride of sodium	2.047
	Soda	0.182
	Carbonate of lime	9.264
	Sulphate of lime	1.321
	Phosphoric acid	0.151
	Oxide of iron, Alumina	5.160
Insoluble in hydrochloric acid		77.2

The river itself carries the fertilizer for the soil, a reddish mud, (hence the name Colorado,) in some respects resembling that of the Rio Grande in New Mexico, (see Part VI, Vol. III, Geographical Surveys west of the One-hundredth Meridian,) and that of the Nile in Egypt; its quantity varies from 0.1 to 0.5 per cent. of the water. After standing several hours the clear water can be drawn from the sediment, and if the former be now evaporated, leaves 0.14 gram solid residue of a weak alkaline reaction, due to a small quantity of carbonate of soda. The larger part of this residue consists of sulphate and chloride of sodium; also traces of lime, magnesia, potassa, and phosphoric acid are present.

This amount of mineral matter is too small to impart any taste to the water, which may be drunk directly from the river, though discolored with mud held in suspension. The same is not true of water from the wells sunk in the adjacent bottom-lands, which generally yield brackish water.

In the following table A the composition is given of the Colorado mud collected at Cottonwood Island, and compared with the mud of the Rio Grande and Nile:

TABLE A.

Constituents.	Colorado.	Rio Grande.	Nile.
Hygroscopic water	3.27	1.890	....
Chemically bound water	1.14	3.122	....
Soluble in hydrochloric acid:			
Potassa	0.103	0.284	0.166
Soda, with trace of lithia	0.074	0.064	0.022
Lime	....	1.479	1.725
Carbonate of lime	12.50	5.190	....
Magnesia	0.69	0.080	0.046
Oxide of iron	....	3.640	8.804
Alumina	2.26	1.308	
Phosphoric acid	0.146	0.092	0.143
Sulphuric acid	trace.	trace.	trace.
Oxide of manganese	trace.	....	....
Insoluble in hydrochloric acid	78.1	82.55	....

None of these sediments contain more than traces of organic matter, another proof that the fertilizing properties mainly depend upon the inorganic material. It will be seen that the Colorado mud contains less potassa than the others, while the amount of phosphoric acid is larger. The proportion of carbonate of lime is unusually large in the Colorado silt, which is certainly a favorable circumstance. Its presence is due to the immense limestone beds through which the river flows.

Of the few streams of Eastern California, the Mohave River is doubtless one of importance. Rising in the San Bernardino Mountains, it takes an easterly course and thus forms a natural highway across the desert to Arizona. Between the sources and

its final sink it disappears five times in the sandy bed and re-appears again, remaining in some places for ten or more miles under ground. In an agricultural point of view the value of this stream is but small, and only the upper third, where a number of ranches at present exist, is worthy consideration.

The bottom-lands are not of great width, but the soil is one of the best, as revealed by the analysis of a specimen taken in the vicinity of Point of Rocks.

Mechanical condition:

Gravel	23.70
Sand	28.00
Silt	34.80
Clay	8.60
Hygroscopic moisture	0.53
Chemically bound water	1.41
	97.04

Chemical constituents:

Soluble in hydrochloric acid.	Potassa	0.214
	Soda	0.093
	Magnesia	0.042
	Carbonate of lime	1.914
	Oxide of iron, Alumina	2.200
	Phosphoric acid	0.247
	Sulphuric acid	0.007
	Chlorine	slight trace.
	Insoluble in hydrochloric acid (granitic)	92.6

ON THE NATURE OF THE SOILS IN THE DESERT.

If upon entering desert tracts one observes an unusually coarse, pebbly surface, and on the other hand a smooth and hard one, like that of a pavement, the inquiry is naturally made how these two extremes happen to touch each other here, while the normal state of the soil appears to be wanting. One needs not to be long in the desert to learn the cause of this. It lies in the action of the sweeping winds upon the dry surface not protected by vegetation. For example, should rain cease to fall in a fertile country, the first consequence would be the disappearance of vegetation, the next the drying up of the soil; whereupon the action of the sweeping winds becomes manifest by carrying away from the surface of the good soil the fine silt as well as the clay particles, which not only contain the principal amount of the fertilizing combinations, but also are the means of retaining the hygroscopic moisture in the soil. Finally, the once fertile fields will present the appearance of a plain of coarse pebbles, underneath which, however, the original soil has preserved its composition. (See below, subsoil of Chukawalla Plain, B.) On the other hand, soils with over 50 per cent. clay, bake by the increasing dryness, harden, and crack, resist the sweeping power of the winds, and remain intact. Such soils, however, although generally rich in the principal fertilizing agencies, are wanting in porosity and are not suited for agriculture. (See below, D.) Only in cases where the sweeping winds are shut out by mountains, or where moisture is spread by a river through bottom-lands, do the soils preserve their original surface-conditions.

In the following the mechanical conditions of several desert soils are given:

	A.	B.	C.	D.
Pebbles	50.2	46.01	11.00	None.
Sand	32.1	19.03	62.01	22.00
Silt	10.4	28.05	22.02	30 01
Clay	4.3	2.01	4.04	40.08
Hygroscopic moisture	1.34	2.65	0.49	3.01
Chemically-bound water	0.50	0.31	0.98	3.84
Organic matters	None.	None.	None.	None.

A.—Soil of the "Forty-mile Desert" near the slopes of the Cerbat Range, taken one foot deep; the surface is a mass of pebbles, while the subsoil shows nothing abnormal.

B.—Soil of Chukawalla Plain; surface exclusively consisting of pebbles and bowlders. The subsoil, however, exhibits no abnormal mechanical conditions, as the above figures show.

C.—Fine silt soil of Ivanpah Valley, protected against the sweeping winds by the Payute Range. The very surface of a portion of said valley consists of fine soil.

D.—Soil of a "dry lake" in the vicinity of Grapevine Ranch, (5 miles north of Mohave River valley,) perfectly bare and baked by the dryness; its chief mass being clay.

The above figures show that a certain, though small, proportion of hygroscopic moisture was still retained, notwithstanding the great dryness of these regions. This explains why some vegetation can succeed in finding existence. Another fact is the absence of organic matter, (*humus*,) which cannot surprise us, if we consider that the latter is formed by decaying vegetation. In the desert, however, no true decay takes place; the small amount of vegetation present dries up after it dies without forming *humus*.

That a soil which from its barrenness would impress the visitor with an idea of inferiority, still may be well provided with the fertilizing combinations, may be seen from the analysis of the subsoil of Chukawalla Plain, (east of Coahuila Valley:)

Potassa	0.281
Soda	0.172
Carbonate of lime	2.043
Magnesia	0.178
Oxide of manganese	trace.
Alumina, Oxide of iron	5.400
Phosphoric acid	0.166
Sulphuric acid	0.00824
Chlorine	traces.
Insoluble in hydrochloric acid, (chiefly granitic)	91.8

Here the phosphoric acid and potassa are present in quantities expected in good fertile soils.

Appendix H 7.

REPORT ON THE GEOGRAPHICAL DISTRIBUTION OF VEGETATION IN THE MOHAVE DESERT.

United States Engineer Office,
Geographical Surveys west of the 100th Meridian,
Washington, D. C., February 14, 1876.

Dear Sir: I have the honor to submit herewith a report upon the distribution of vegetation in the Mohave Desert. Inasmuch as conditions have been observed, rarely occurring elsewhere, the report may prove of some special interest.

Thanks are due to Dr. Vasey, botanist of the Agricultural Department, who kindly determined a large number of the species collected.

Very respectfully, your obedient servant,

Oscar Loew.

Lieut. Geo. M. Wheeler,
Corps of Engineers, in charge.

The zones of vegetation appear to be more sharply defined in a dry country than in one blessed with sufficient rain. With regard to the Mohave Desert, not only the lower and the upper lines of these zones are found very marked, but also the change of flora with the latitude.

A decrease in latitude is connected in the Mohave Desert by no means with an increase in altitude, as is the rule in most climates; and with some plants just the reverse can here be observed. Thus you find the piñon (*pinus edulis*) upon the San Bernardino Mountains in an altitude of 5,000 feet and latitude 34° 10′, while in latitude 36° this tree is not seen below 8,000 feet altitude. Quite an analogous case was observed by parties of your expedition in 1874. The lower line of the piñon is found in Southern Colorado to be of 200 feet higher altitude than in Southern New Mexico. The distribution of vegetation in the dry regions is determined more by the relative humidity of the air than by the mean temperature or atmospheric pressure.

The southern portion of the Mohave Desert has more rain than the northern, and this is the main reason that the ranges of the latter are distinguished by a great degree of barrenness even in considerable heights. If a line were drawn from the Gulf of Mexico to west-northwest, one easily conceives how the more northern portions of the Mohave Desert, comprising Death Valley, Panamint Valley, Funeral and Telescope Ranges, and a great portion of Inyo County, California, fall beyond the reach of the moist monsoon, (see Chapter on the Meteorological Conditions of the Mohave Desert;) hence

summer rains seldom fall in that part. If, on the other hand, is taken into consideration the Sierra Nevada, with nearly 15,000 feet altitude, bordering the northern portions of the Mohave Desert on the western side, we can again understand why the northwest winds prevailing in winter time arrive deprived of their moisture in the desert, and hence the scarcity of winter rains.

That some plants depend, as the main condition of their existence, upon very dry climates, is proved by the *Larrea Mexicana*, a plant that grows in considerable number in many parts of the Mohave Desert, but not in a single specimen in the coast counties; indeed, standing on San Gorgonio Pass, that forms a point of separation between the desert and the coast region, you may see many specimens of this plant on looking toward the *east*, but not a single one between this point and the coast to the *westward*.

Most striking, also, is the sudden disappearance of the Yucca-tree (*Yucca brevifolia*, Eng.*) as soon as the natural boundaries between the desert and the coast counties are crossed. Yet, while this plant is confined to respectively narrow zones of limited altitudes, the *Larrea Mexicana* ranges from about sea-level up to 4,400 feet, and is so widely spread that it may be assumed that the botanical boundaries of the Mohave Desert are defined by the range of *Larrea Mexicana*.

At every mountain-chain crossed, the lower and upper lines of the zones of the most striking vegetable forms were determined by a pocket aneroid.† These lines, of course, shift somewhat—sometimes several hundred feet—with the direction of the mountain-slopes, extent of the plateau, or proximity of deep and hot valleys. The following table will show approximately the average zones of the more conspicuous plants.

Distribution of plants in the Mohave Desert.

Name of species.	Altitude of zone.		Latitude.	Remarks.
	Lower line.	Upper line.		
Yucca brevifolia	3,400	4,500	34° to 36° 20′	On the western slopes of the Payute Range, lower line = 4,200.
Opuntia ramosissima	2,000	5,000	32° 20′ to 35° 40′	In southern regions, lower line = 800.
Opuntia arborescens	3,600	5,000	Widely spread	*Opuntia Strigii*, *Cereus Berlandieri*, *Yucca baccata*, and *Ephedra antisyphilitica* occupy the same region.
Cereus giganteus	....	3,500	Not north of 33° 40′.	Prefers lime soils and rocky slopes.
Echinocactus cylindraceus	....	2,300	33° 30′ to 35° 40′	Very isolated.
Mammillaria barbata	600	3,500	33° to 36°	
Fouquieria splendens	Sea-level?	2,500	Not north of 34°	*Cercidium floridum*, *Parkinsonia microphylla*, *Asclepias subulata*, and *Acacia Wrightii* occupy the same regions.
Dalea spinosa	....	800	Not north of 35° 10′.	In southern regions, upper line = 2,000.
Acacia Rœmeriana	3,900	4,500	34° to 36° 20′	*Holocantha Emoryi* occupies the same regions.
Juniperus occidentalis	3,900	5,400	Ranges between wide latitudes.	Upper line about 8,000 in the northern part of Mohave Desert.

While it is seen from the foregoing table how well certain species are fixed between lines of altitudes, other species, as for instance, *Pectis angustifolia*, *Datura meteloides*, *Cucurbita Californica*, range between very wide limits; they were observed in moist spots in altitudes of 600 as well as 5,000 feet, their existence depending upon an increased moisture in the soil.

The character of the vegetation of the Mohave Desert resembles in many respects that of Southern Arizona, especially of the Gila Valley.

While the changes of the vegetation with latitude and altitude are well marked, those depending upon the different conditions of the ground are still more striking; the clay soil, the sandy dry wash, the coarse pebbly plain, the salt flat, the loose sand-hills, the rocky slopes, each nourish a different flora, however poor. In the following list, a classification in this direction is attempted:

The chief representatives of the Colorado Valley from the mouth of the Grand Cañon of the Colorado to the southern spurs of the Riverside Mountains, are: *Atriplex hymenilyttra; Atriplex polycarpa; Palafoxia linearis; Psathirotes ramosissima; Physalis*

* Described but few years ago by Engelmann, (see Clarence King's Report on the Explorations of the Fortieth Parallel, vol. 3.) I have never seen this most singular plant in Texas, New Mexico, or Arizona.

† These observations comprise the San Bernardino, Opal, Providence, Cerbat, and Colorado Ranges.

lobata; Lippia cuneifolia; Aster spinosus; Sesbania macrocarpa; Abronia Amaranthus; Pluchea Sarcostemma; Algarobia glandulosa, Strombocarpa pubescens, (the two species of Mesquit-trees;) *Salix longifolia, Tessaria borealis, Baccharis cœrulescens, Baccharis salicina,* (form dense brush along the river-margins;) *Malvastrum marubioides; Datura meteloides; Cucurbita Californica; Xanthium strumarium; Suæda diffusa; Panicum crus-galli; Chloris alba; Allionia incarnata; Populus monilifera; Lygodesmia Garrya.*

Flora of the Coahuila (Cabezon) Valley: *Baccharis salicina; Baccharis Emoryi; Aplopappus caricifolius; Dicoria canescens; Algarobia glandulosa; Halostachys occidentalis; Petalonix Thurberi; Linocyris caricifolia; Atriplex lentiformis;* a palm species, (*Brahea?*).

Flora of the Dry Washes: *Cercidium floridum; Parkinsonia microphylla; Chilopsis linearis; Krameria parvifolia; Acacia Wrightii; Asclepias subulata; Dalea spinosa.*

Flora of dry sand-hills: *Coldenia Palmeri; Pleuraphis Jamesii; Eriogonum inflatum; Tricuspis pulchella,* (sand-grass;) *Heptis Emoryi, Mammillaria barbata; Aristida,* (galleta-grass;) *Chlorizanthe rigida; Boutelona,* (sand-grass;) *Psathirotes annua.*

Flora of the coarse pebbly plain and rocky slopes: *Larrea Mexicana; Yucca brevifolia; Opuntia ramosissima; Echinocactus cylindraceus;* Yucca bacata; Atriplex canescens; Opuntia arborescens; Fouquieria splendens.*

Flora of clayey soil charged with sodium salts: *Halostachys occidentalis; Salicornia; Bryzopyrum spicatum.*

Specific forms of the coast and adjacent regions: *Frankenia grandifolia; Œnothera viridescens; Styphonia serrata; Photinia arbutifolia; Artemisia Californica; Zauschneria Californica; Mesembryanthemum crystallinum; Abronia umbellata; Rhus aromatica; Isomeris arborea; Eriogonum fasciculatum; Arctostaphilos tomentosa; Cerasus salicifolia.*

In reviewing the specific floral characters of the desert, a series of most singular forms arrests the attention. Indeed, what surprising forms are the *Fouquieria splendens,* the *Dalea spinosa, Krameria parvifolia, Yucca brevifolia, Cereus giganteus!* Truly, who once has seen these striking characters will forever keep their aspects in memory. They bear testimony of their struggle for existence, a struggle, not with other species, but with a scorching and merciless climate, in consequence of which the main organs supporting the evaporation of moisture—namely, the leaves—were gradually diminished in size, (*Algarobia, Strombocarpa,*) or disappeared entirely, (*Cactus,*) or became *rudimentary* and falling off soon after their development, (*Dalea, Cercidium,*) or became covered with a thick stratum of fiber, (*Yucca,*) or so charged with resinous matters as to make the evaporations of small particles of water quite impossible, (*Larrea.*) But, as the leaves are the principal organs of assimilation, the first condition of life and growth of plants, a substitute was necessary where they disappeared; and the trunk, branches, and thorns assumed the vital functions. To this end, the bark and surface of such trees are provided with a green layer of chlorophyl. What a singular impression make *Dalea* and *Cercidium*—green trees without leaves!

APPENDIX H 8.

REPORT ON THE ORNITHOLOGY OF THE PORTIONS OF CALIFORNIA VISITED DURING THE FIELD-SEASON OF 1875 BY H. W. HENSHAW.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, June 10, 1876.

SIR: I have the honor to transmit the following report upon the ornithology of the portions of California visited by me during the field-season of 1875.

As a field for ornithological research, the region as a whole was by no means a new one, parts of California having been traversed by several governmental parties, and more or less extensive collections of birds made by the naturalists of the several surveys. The more southern portions of the State, however, those visited by us, were believed to be possessed of much interest, special importance attaching to the region lying about Mount Whitney as being less known, and hence likely to present features of value when studied with a view to its avian fauna.

While these expectations were not wholly borne out, the results obtained are believed to be possessed of considerable value in their bearing on the distribution of the many species that came under observation. Quite a number of birds were found at points considerably farther south than had previously been chronicled, and the range of others extended westward. Such instances are mentioned in detail under the re-

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* A specimen of this singular Cactus, nestling amid the barren rocks, with but very little soil accumulated between them, is shown in the accompanying figure.

spective species. Not a small portion of the country traversed by the Survey was found to be remarkably destitute of birds, not only as regards the number of species, but also the number of individuals seen was small. In some sections, as on the dry and arid plains, the nature of the country itself furnishes the cause of this; but elsewhere, I am inclined to attribute much of this paucity of bird life to the presence of sheep and to the effect they have had on the vegetation, for over a very large region in Southern California these animals exist in such numbers as to fairly render their pasture-grounds little else save howling deserts, attractive neither to themselves nor to any other living creature. Not only is this true of the lower, more accessible, portions, but it was found to be the case in the lofty mountains of the Sierra, where thousands of sheep are driven in summer, their combined numbers resulting almost in the obliteration of every green thing within their reach. Not only are destroyed the plants and flowers upon which depend the presence of insects, which furnish to many birds a large proportion of their food; but this is accompanied by the destruction of much of the undergrowth, so essential to the mode of life of many of the smaller species. In no other way could I account for the fewness of birds in districts that seemed possessed of all the natural requisites to attract them in great numbers, but where the painful desolation brought about from this cause was accompanied by a marked scarcity of feathered life.

The field-work began June 1, at which time Doctors Rothrock, Loew, and myself visited the island of Santa Cruz, the most inland of the group of islands lying in the Santa Barbara Channel. The two weeks spent on the island were mostly occupied in making general collections in natural history. The surface of the island is extremely rough, and broken up in every direction by rocky ridges, which render all travel exceedingly difficult; and in the little time that was spent in collecting the land-birds it is not probable that by any means all of the species were found. All that came under notice occur on the mainland, and differ in no respect. Many species of sea-birds resort to these islands for the purpose of reproduction; fewer, however, to Santa Cruz than to the others.

Two species, *Uria columbe* and *Fratercula cirrhata*, were found to breed here; this fact being of interest as indicating a range at this season much farther south than suspected before. Among other objects of value obtained here was a series of specimens of the little "Island Fox," (*Vuepes littoralis*,) an animal but little known to naturalists, and of great rarity in collections. They inhabit the islands in very great numbers, and are found, as far as known, nowhere else. A quite extensive collection of fish and mollusks was also made.

In connection with our work on the island, it is a pleasant duty to mention the courtesy and many favors our party received from the officers of the Hassler, who one and all interested themselves in the object of our visit, and contributed much to its success. Indeed, it was through the kindness of Capt. H. C. Taylor that we were enabled to visit Santa Cruz, which otherwise would have been most difficult.

Upon joining the main party at Los Angeles, June 15, the original plan for the season's work was changed so as to admit a small natural-history party in charge of Dr. Rothrock to return to Santa Barbara, and there meeting Dr. Yarrow to prosecute our work in connection with archæological researches in this neighborhood. The locality was found to be extremely rich in Indian mounds used as burial-places, and, as a result of labors here, a large collection of Indian remains and implements was exhumed.

The collections in zoology made here were also quite large, including not only a large number of birds, but also many insects, fish, reptiles, &c., for many of which we are indebted to the zeal and interest displayed by Mr. C. J. Shremaker.

Leaving Santa Barbara July 13, we proceeded to old Fort Tejon, there joining the main party. About this point rather more than a month was occupied, two short trips being made to the neighboring mountains, where several rare and interesting birds were found.

September 4 the party set out for the Mount Whitney country, where the time up to the middle of October was taken up. The mountains of this region are, many of them, well wooded, mostly with pine and tamerack, while the streams, as usual in these high altitudes, were more or less densely fringed with deciduous vegetation. The avian fauna was found at this time to be quite limited in the aggregate of species, and, as a rule, not numerously represented in individuals. The absence of the Warbler tribe (*Sylvicolidæ*) was especially noticeable. The only ones of this family seen here were the *Helminthophaga celata*, *Dendroica audubonii*, *D occidentalis*, and *Myiodioctes pusillus*, all of them being comparatively rare.

Returning from Mount Whitney, the remaining interval up to October 15 was spent near Kernville and at Walker's Basin, when the field-work ended.

The season's collection of birds amounted to 700 specimens, representing 127 species. In addition, a considerable number were observed in greater or less numbers, and find mention in the report. A list of the specimens, with the localities where collected, follow each species; and, in the case of those less known, careful measurements are given.

A synonymical list follows such of the species as were not thus treated in our previous report.

In most instances, the classification followed is that given by Baird, Brewer, and Ridgway in their recent work on North American Birds. In the Waders and Water-birds, that adopted by Dr. Coues is taken.

TURDIDÆ.—THRUSHES.

1. *Turdus migratorius*, L.—Robin.

Nowhere in the region south of San Francisco does the Robin appear to be a common bird, and, indeed, it was rarely seen by us till after September, when they were found here and there in the mountain-valleys, not in large flocks but leading rather a hermit life, and subsisting much upon berries.

2. *Turdus nævius*, Gm.—Varied Thrush; Oregon Robin.

Turdus nævius, Newb., P. R. Rep., vi, 1857, 81.—Bd., B. N. A., 1858, 219.—Heerm, P. R. R. Rep., x, 1859, pt. vi, 45.—Bd., Zool. Ives's Exped., 1860, 5 (Colorado Valley).—Xantus, Proc. Phila. Acad. Nat. Sci., 1859, 190 (Ft. Tejon, Cal.)—Coop. & Suckl., P. R. R. Rep., vol. xii, pt. ii, 1860, 172.—Coues, Proc. Phila. Acad. Nat. Sci., 1866, 88 (Colorado Valley).—Coop., Am. Nat., iii, 1869, 31 (Montana).—Coop., B. Col., 1, 1870, 10.—Coues, Key N. A. B., 1872, 72.—B., B., & R., N. A. B., i, 1874, 29.

In California, this Thrush is found only in the character of a fall and winter visitor, returning with the spring to congenial haunts in the far north, there to pass the season of reproduction. It is usually common about San Francisco in winter, and not a few suffer at the hands of the gunners, and are brought into the markets and sold for the table. Though finding its way to the south of this point, it is in diminishing numbers, and in the foot-hills and low mountains near Caliente it was far from numerous during the last of October and November. They kept in small flocks, and were exceedingly shy and suspicious. In habits, they seem to correspond pretty closely to the Robin, as does their food, which, as with that species, consists largely, in the fall, of berries of various roots.

No.	Sex.	Locality.	Date.	Collector.
642	♂ ad.	Walker's Basin, California	Nov. 5	H. W. Henshaw.
643	♀ ad.	......do	Nov. 5	H. W. Henshaw.

3. *Turdus pallasi*, Cab., var. *nanus*, Aud.—Dwarf Thrush Hermit.

Of this little Thrush none were seen previous to the very last of September. After this time, every little willow-thicket along the mountain-streams contained one or more, the migration being at its height from about the 5th to the 15th of this month. I cannot but think that both Drs. Heermann and Cooper had in mind some other species, probably *ustulatus*, when they spoke of the *Turdus nanus* as breeding about and to the south of San Francisco. In his description of the spotted eggs of this species, Dr. Cooper unquestionably had in mind those of the *T. ustulatus*, the eggs of the *T. nanus* being perfectly plain, and it seems most likely that this error of identification was carried still further, and all of his statements as to breeding habits and summer habitat be referable to the *T. ustulatus*. In the interior, in the same latitude, the Dwarf Thrush occurs only as a migrant. I am inclined to believe that the breeding of this bird so far south as California, even in exceptional instances, has yet to be substantiated. It certainly does not as a rule occur by any means so far south in summer.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
509	♂	Near Mount Whitney, Cal	Sept. 29	H. W. Henshaw	3.58	2.72	0.47	1.15
514	♂	......do	Oct. 3	....do	3.67	3.15	0.54	1.10
515	♀	......do	Oct. 3	....do	3.53	2.87	0.48	1.10
516	♀	......do	Oct. 3	....do	3.32	2.65	0.48	1.12
517	♂	......do	Oct. 3	....do	3.33	2.80	0.51	1.06
535	♂	......do	Oct. 9	....do	3.31	2.85	0.50	1.12
536	♂	......do	Oct. 9	....do	3.52	2.87	0.48	1.12
542	♂	......do	Oct. 10	....do	3.42	2.65	0.54	1.06
543	♂	......do	Oct. 10	....do	3.50	2.81	0.53	1.14
559	♂	......do	Oct. 10	....do	3.47	2.92	0.52	1.16

4. *Turdus swainsoni*, Cab., var. *ustulatus*, itt.—Oregon Thrush.

Turdus ustulatus, Bd., B. N. A., 1858, 215.—Coop. & Suckl., P. R. R. Rep., vol. xii, pt. ii, 1860, 171.—Coop., B. Cal., i, 1870, 5.—Lawr., Proc. Bost. Soc. Nat. Hist., June, 1871 (Tres Marias).
Turdus swainsoni var. *ustulatus*, Coues, Key N. A. B., 1872, 73.—B., B., & R., N. A. B., 1874, 16.—Nelson, Proc. Bost. Soc. Nat. Hist., vol. xvii, 1875, 355 (California).

This race of the more eastern and northern Swainsoni Thrush is found in summer throughout California, where it breeds, resorting to the valleys and lowlands generally, rather than to the mountainous districts. It was in full song about San Francisco the last of May, and the species was probably at this time nesting. Its habits and very nature appear to be different from its nearest ally, the Swainsoni Thrush. Unlike that bird, instead of finding a congenial home only in the solitude of the remote northern wilds, it is perfectly content to live a near neighbor to, and a companion of, man, and dwells as contentedly as the Robin in the gardens and orchards on the outskirts of the towns. Its song I frequently heard coming from the midst of the shrubbery that environs the houses. It is exceedingly like the well-known strains of the Wilson's Thrush, though seeming to lack something of the depth of tone and wildness which gives that song its chief charm. It is, too, rather shorter. At Santa Barbara, I found the young fully fledged by the last of June.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
66	♂ ad.	Santa Barbara, Cal	June 25, 1875	H. W. Henshaw	3. 87	3. 30	0. 57	1. 21
70	♀ ad.	do	June 26, 1875	do	3. 73	3. 17	0. 57	1. 17
71	♂ jun.	do	June 26, 1875	do				
147	♂ ad.	do	June 29, 1875	do	3. 73	3. 05	0. 52	1. 14
148	♀ ad.	do	June 30, 1875	do	3. 72	3. 05	0. 57	1. 12

5. *Mimus polyglottus*, L.—Mocking-bird.

According to Dr. Cooper, the Mocking-bird is said to occur in California as far north as Monterey. Along our route from Los Angeles to Santa Barbara, it was seen on a few occasions only, chiefly on the dry plains, where the prickly pears and other cacti grew in abundance. The Sage-thrasher, (*Oreoscoptes montanus*,) according to Dr. Heermann, is not rare about San Diego. It probably intrudes only into the extreme southern portion of the State.

6. *Harporynchus redivivus*, Cabanis.—California Sickle-bill Thrush.

Harporynchus redivivus, Bd., B. N. A., 1858, 349.—Xantus, Proc. Phila. Acad. Nat. Sci., 1859, 191.—Coop., B., Cal. i, 1870, 15.—Coues, Key N. A. B., 1872, 75.—B., B., & R., N. A. B., i, 1874, 45.

This Thrush was found in various localities throughout Southern California, where it is a constant resident. Though preferring the lowlands, we occasionally saw these birds in the dense chaparral that clothes the bases of many of the low mountains. Like the others of this singular genus, it is eminently terrestrial in its habits, its stout, s ong claws, aided by its heavy bill, being well adapted for scratching among the leaves and *débris* for all sorts of insect life. It is shy and timid, and covets the seclusion of the hedges and thickets at all times. When alarmed, its wings serve to carry it for a short distance, till it has gained some covert, when its active feet enable it to keep out of sight by dodging here and there till its safety is assured.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
45	Ad.	Santa Barbara, Cal	June 25	H. W. Henshaw	3. 65	5. 62	1. 47	1. 52
46	Ad.	do	June 25	do	3. 95	5. 45	1. 39	1. 57
95	Jun.	do	June 27	do				
203	♂ jun.	do	July 6	do				
241	♀ jun.	do	July 10	do				
663	♀	do	Nov. 9	do	4. 12	5. 65	1. 63	1. 53
741	♂ ad.	do	June 14	do	4. 00	5. 58	1. 55	1. 48

CINCLIDÆ.—WATER-OUZELS.

7. *Cinclus mexicanus*, Sw.—*Water-ouzel.*

Throughout the mountains of the West, it needs only the presence of a stream of water, whirling and foaming over its rocky bed through cañon and pass, to surely attract this

little nondescript to take up its abode on its banks. It occurs on many of the streams of the Sierras, numbers occupying the same reach of stream when food is abundant.

No.	Sex.	Locality.	Date.	Collector.
474	♂	Near Mount Whitney, Cal	Sept. 15	H. W. Henshaw.
475	♂	......do	Sept. 15	Do.

SAXICOLIDÆ.—STONE-CHATS.

8. *Sialia mexicana*, Sw.—Western Bluebird.

This species replaces in California the common Red-breasted Bluebird of the East, and is very common.

No.	Sex.	Locality.	Date.	Collector.
266	♀ jun.	Tejon Mountains, Cal	Aug. 2	H. W. Henshaw.
273	♂ jun.	......do	Aug. 2	Do.
303	♂ ad.	Fort Tejon, Cal	Aug. 7	Do.
304	♀ jun.	......do	Aug. 7	Do.
308	♂ jun.	......do	Aug. 7	Do.
553	♂ ad.	Near Mount Whitney, Cal	Oct. 11	Do.
600	♂ ad.	......do	Oct. 23	Do.
659	♂ ad.	......do	Nov. 5	Do.
755	Jun.	......do	July —	Do.

9. *Sialia arctica*, Sw.—Rocky Mountain Bluebird.

Apparently much rarer than the preceding species; indeed, I am not positive that I detected its presence at all, though a flock of Bluebirds seen in the high Sierras late in October were supposed to be of this species. This seems the more probable, as Dr. Cooper speaks of finding it numerous about Lake Tahoe and the summits of the Sierras in September.

SYLVIIDÆ.—SYLVIAS.

10. *Regulus calendula*, (L.)—Ruby-crowned Kinglet.

This species is very abundant during the migrations, and may perhaps be yet found breeding in the high mountains of Southern California, as it probably does in the more northern half of the State.

No.	Sex.	Locality.	Date.	Collector.
506	♂	Near Mount Whitney, Cal	Sept. 26	H. W. Henshaw.
519	♂ jun.	......do	Oct. 3	Do.

11. *Polioptila cœrulea*, (L.)—Blue-gray Gnatcatcher.

The neighborhood of Fort Tejon was the only locality where this Gnatcatcher was seen. It was here particularly numerous, the bushes along the sides of the cañons being for some reason or other especially favored by their numbers. Neither here nor elsewhere was the closely-allied species *P. melanura* detected.

No.	Sex.	Locality.	Date.	Collector.
257	♀ jun.	Fort Tejon, Cal	July 27	H. W. Henshaw.
324	♂ jun.	......do	Aug. 8	Do.
325	♂ jun.	......do	Aug. 8	Do.
323	♂ jun.	......do	Aug. 8	Do.
326	♀ jun.	......do	Aug, 8	Do.
327	♀ jun.	......do	Aug. 8	Do.

CHAMÆODAE.—GROUND WRENS.

12. *Chamoea fasciata*, Gamb.—The Ground Wren.

Chamœa fasciata, Bd., B. N. A., 1858, 370.—Xantus, Proc. Phila. Acad. Nat. Sci., 1859, 191.—Coop., B., Cal., i, 1870, 39.—Coues, Key N. A. B., 1872, 79.—B., B, & R., N. A. B., i, 1874, 84.—Nelson, Proc. Bost. Soc. Nat. Hist., vol. xvii, 1875, 356 (California).

The Ground Wren appears to inhabit Southern California at large, and was detected by us at several widely-separated points both in the Coast range and the Sierras. Its

habits are a queer compound, and, though often suggestive of the Titmice, with which, too, its colors are somewhat correspondent, they yet resemble still more closely the Wrens, while the bird has characteristics borrowed from neither of its prototypes, but all its own.

I first saw the species in July, in a tangled growth of vines and bushes, close to the seashore near Santa Barbara. So careful, however, were they to keep themselves close within the friendly shelter of matted undergrowth that, though I made out from their voluble sputterings that a whole family was there congregated, I was unable to push a very close acquaintance. Subsequently I found another group in a small cluster of willows that fringed a mountain-rivulet near Fort Tejon. A few faint, querulous, sputterings from the center of the clump first attracted my attention, and, sitting down, I awaited patiently till I could catch a glimpse of their authors. After a few moments further silence on my part they began to approach nearer and nearer, till, ere long, I saw one little brown bunch of feathers balancing itself on the upright stem of a willow and peering cautiously about, all the while communing with itself and its fellows in quaint undertones. They appear to be fond of each others' society, and socially inclined toward other birds of very different habits, for I never saw or heard one without soon learning of the presence of others hard by, while, late in the fall, I often found several adding their quota to the flocks of Sparrows and Snowbirds in their journeyings through the chaparral thickets on the mountain-sides.

They spend most of their time seeking food about the roots of bushes, and especially apt were they to be found in willow-clumps along the stream. Enough of their time is passed upon and near the ground to make the name of Ground Wren an appropriate one.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
380	♀ ad.	Tejon Mountains, Cal.....	Aug. 17	H. W. Henshaw	1. 27	3. 22	0. 40	1. 00
399	♂ ad.	......do	Aug. 19	....do	2. 43	3. 98	0. 42	1. 04
400	♀ ad.	......do	Aug. 19	....do	2. 40	3. 60	0. 40	1. 03
688	♂	Walker's Basin, Cal	Nov. 10	....do	2. 40	3. 40	0. 43	1. 00
704	♂ ad.	......do	Nov. 10	....do	2. 45	3. 73	0. 43	1. 00
705	♀	......do	Nov. 11	....do	2. 35	3. 58	0. 43	0. 88

PARIDÆ.—TITMICE.

13. *Lophophanes inornatus*, (Gamb).—Gray-tufted Titmouse.

This species appears to be a resident throughout Southern California, and is numerous here, as indeed almost everywhere in the Tar West.

No.	Sex.	Locality.	Date.	Collector.
146	♂ jun.	Santa Barbara, Cal	June 29	H. W. Henshaw.
249	♂	Ojai Creek, Cal	July 17	Do.
264	♂	Fort Tejon, Cal	July 27	Do.
322	♀	......do	Aug. 7	Do.
353	♂ jun.	......do	Aug. 10	Do.
393	♂ ad.	......do	Aug. 17	Do.
658	♀	Walker's Basin, Cal	Nov. 5	Do.

14. *Parus montanus*, Gamb.—Mountain Chickadee.

This appears to be the commonest representative of its tribe in Southern California, inhabiting chiefly the coniferous regions, and rarely descending to the low country.

The *Parus occidentalis* appears not to occur in the southern portion of the State; none at least were detected by us, nor do I find it quoted from this region. Its proper habitat is the Columbia River region and to the northward.

No.	Sex.	Locality.	Date.	Collector.
489	♀	Near Mount Whitney, Cal	Sept. 19	H. W. Henshaw.
490	♂ jun.	......do	Sept. 19	Do.
522	♂	North Fork Kern River, Cal	Oct. 7	Do.
523	♀	......do	Oct. 7	Do.
524	♂	......do	Oct. 7	Do.
525	♂	......do	Oct. 7	Do.
550	♀	Near Mount Whitney, Cal	Oct. 10	Do.

15. *Psaltriparus minimus*, (Towns).—Least Titmouse.

Parus minimus, Townsend, Jour. A. N. Sci. Phila., vii, 11, 1837, 190.
Psoltriparus minimus. Bd., B. N. A., 1858, 397.—Coop. & Suckl., P. R. R. Rep., vol. xii, pt. 11 1860, 189.—Coop., B. Cal., i, 1870, 48.—Coues, Key N. A. B., 1872, 82.—B., B., & R., N. A. B. 1874, 109.—Nelson, Proc. Bost. Soc. Nat. Hist., vol. xvii, 356 (California).
Psaltria minima, Heerman, P. R. R. Rep., xvi, 38.

This Titmouse, in external appearance so much like the allied form var. *plumbeus* from Arizona and the Southern Rocky Mountains, is its exact counterpart in habits and notes. Like that bird, it shuns the coniferous trees for which most of the family are so partial, and is found in the shrubbery and chaparral of the open country, particularly on the edges of cañons and along the broken, rocky ridges. In large flocks of so many individuals that the bushes seem sometimes fairly laden with the tiny busy-bodies, they move rapidly over the country, launching themselves in short flights from clump to clump, their notes telling of their whereabouts and serving to keep the flock well together. The sight of a wounded or dead comrade is sufficient to put the whole company in a flutter of commotion, and as they flock in to inspect their unfortunate associate their cries are redoubled, while they descend to the ground and vainly endeavor to ascertain the cause of the trouble and to be of assistance.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
64	♂	Santa Barbara, Cal	June 25	H. W. Henshaw.	1.80	2.16	0.28	0.63
112	♂ jun.	......do	June 27	....do	1.98	2.14	0.29	0.62
113	♂	......do	June 27	....do	1.75	2.05	0.29	0.63
114	♂ jun.	......do	June 27	....do	1.85	2.12	0.29	0.63
115	♂ ad.	......do	June 27	....do	1.85	2.17	0.30	0.63
305	♀	Fort Tejon, Cal	Aug. 7	....do	1.77	2.07	0.27	0.68
306	♀	......do	Aug. 7	....do	1.77	2.05	0.29	0.65
607	♂ ad.	......do	Aug. 7	....do	....	......	......	....
758	ad.	..... do	Aug. 7	....do	....	......	......	....
669	♂	Walker's Basin, Cal	Nov. 10	....do	1.92	2.18	0.30	0.60
675	♀	......do	Nov. 10	....do	1.95	2.16	0.26	0.59
676	♂	......do	Nov. 10	....do	1.98	2.18	0.29	0.63
677	♂	......do	Nov. 10	....do	1.93	2.30	0.27	0.60
678	♀	......do	Nov. 10	....do	1.88	2.17	0.27	0.63
679	♂	......do	Nov. 10	....do	1.93	2.25	0.30	0.63
680	♂	......do	Nov. 10	....do	1.90	2.15	0.30	0.63
681	♂	......do	Nov. 10	....do	1.98	2.16	0.26	0.63
682	♂	......do	Nov. 10	....do	1.88	2.25	0.28	0.70
684	♂	......do	Nov. 10	....do	1.90	2.20	0.28	0.64
686	♂	......do	Nov. 10	....do	1.90	2.20	0.28	0.67
687	♀	......do	Nov. 10	....do	1.95	2.30	0.30	0.63
685	♂	......do	Nov. 10	....do	1.97	2.28	0.30	0.66
756	....	......do	Nov. 10	....do	1.92	2.15	0.26	0.62
757	......	......do	Nov. 10	....do	1.93	2.28	0.28	9.63

SITTIDÆ.—NUTHATCHES.

16. *Sitta carolinensis*, Gm., var. *aculeata*, Cass.—Slender-billed Nuthatch.

This species was found numerously in the pine region of both the Coast and Sierra ranges. I am inclined to think it is a resident in the mountains well down to the southern border of the State, as is the case in Arizona.

No.	Sex.	Locality.	Date.	Collector.
554	♂	Near Mount Whitney, Cal	Oct. 10	H. W. Henshaw.
555	♀	......do	Oct. 10	... do

17. *Sitta canadensis*, L.—Red-bellied Nuthatch.

This Nuthatch is possessed of a range considerably more northerly than any of the others of the family. Its occurence, therefore, in the southern sierras is to be looked upon perhaps as rather unusual, and possibly it may be only found here as migrant and in winter. I found it breeding, however, in Southern Colorado, where it was not rare, which would render the supposition of it remaining in the high mountains of Southern California more probable. It appeared to be not uncommon in the pine region near Mount Whitney in October.

No.	Sex.	Locality.	Date.	Collector.
528	♀ jun.	Near Mount Whitney, Cal	Oct. 7	H. W. Henshaw.
38	♀ jun.	......do	Oct. 9	....do

18. *Sitta pygmæa*, Vig.—California Nuthatch.

This is by far the most abundant of the three species seen in California, and was common everywhere where the presence of pines affords them the hunting-grounds they most affect.

CERTHIIDÆ.—CREEPERS.

19. *Certhia familiaris*, L., var. *americana*, Bon.—Brown Creeper.

The Creeper breeds in the mountains of Southern California, where I took a young bird in the first plumage near Fort Tejon, August 2. It is, however, not common till late in the fall, when their numbers are increased by the arrival of migrants from more northern breeding-grounds.

No.	Sex.	Locality.	Date.	Collector.
759	♂	Tejon Mountains, Cal	Aug. 2	H. W. Henshaw.

TROGLODYTIDÆ.—WRENS.

20. *Campylorynchus brunneicapillus*, Lafr.—Cactus Wren.

Only in a few localities was this species met with, though its absence in Southern California as high as latitude 35° or 36° may be attributed chiefly to the lack of cactus plains, the cacti being almost a necessity in the domestic economy of the bird, both because these plants furnish it with its favorite hunting-grounds, and because it is in their branches that they love to place their nests. Up to the latitude indicated the species may be looked for with confidence whenever is found a district well supplied with these plants. One or two individuals were shot a few miles northeast of Kernville, but with plumage in such a state of moult that they were not considered worth preserving.

21. *Salpinctes obsoletus*, (Say).—Rock Wren.

The Rock Wren is perhaps not as abundant throughout Southern California as in many portions of the central region, yet it is found here and there in varying numbers, inhabiting the rocky, sterile, waste lands, which few other species care to share with it. It was noted also on the island of Santa Cruz.

No.	Sex.	Locality.	Date.	Collector.
633	♀	Near Sunday Peak, Cal	Oct. 25	H. W. Henshaw.
703	♀	Walker's Basin, Cal	Nov. 10	....do

22. *Catherpes mexicanus*, (Swains.), var. *conspersus*, Ridgw.—White-throated Rock Wren

Probably the latitude of San Francisco forms about the northward limit of this species, thus coinciding with its known extension in the interior. It was detected by our parties as far north as the neighborhood of Mount Whitney, where it was tolerably numerous, being only seen among the broken masses of rocks that lie at the bases of the perpendicular cliffs or along their faces. It was detected, too, at various points in the Coast range, so that its diffusion over Southern California may be said to be general.

Of all its tribe, save perhaps the Winter Wren, this species is the most liable to be overlooked, where, too, it may be tolerably common. To a preference for the wild solitudes of the mountains it adds a shy, suspicious nature, which prompts it to hide away from observation and all chance of danger whenever anything of a suspicious character is observed.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
706	♂	Walker's Basin, Cal	Nov. 10	H. W. Henshaw.	2.30	2.25	0.85	0.71

23. *Troglodytes bewickii* (Aud.), var. *spilurus*, (Vigors).—Western Mocking-bird.

Troglodytes spilurus, Vig., Zool. Beechey's Voyage, 1839, 18, pl. 4, f. 1 (California).
Thryothorus spilurus, Coop., B. Cal., i. 1870, 69.
Troglodytes bewickii, Newb., P. R. R. Rep., vi, 1857, 80.—Herm., ibid., x, 1859, pt. vi, 40.—Coop. & Suckl., ibid., vol. xii, pt. ii, 1860, 189.
Thryothorus bewickii, var. *spilurus*, Bd., Rev. N. A. B , 1864, 126.—Coues, Key N. A. B., 1872, 86.—B., B., & R., N. A. B., 1874, 147.—Nelson, Proc. Boston Soc. Nat. Hist., vol. xvii, 357 (California).

In one or another of its three varieties, this bird is represented quite across the United States. The Bewick's Wren in the east, and its white-bellied variety (var. *eucogaster*) in the middle region, are both quite southern in their habitats, much more so than the extreme western form (var. *spilurus*), which, according to Dr. Cooper, winters in the mild regions as far to the north as Puget Sound

Throughout the southern half of California it is a common resident during the summer, preferring to inhabit the more elevated regions, and descending thence to the lowlands to pass the winter.

It is a bird of the rather open districts, at least as compared with some others of the family, and, when its breeding duties have been fulfilled, wanders a great deal over the country at large. It is apt to be found in company with the restless flocks of Sparrows and Snowbirds, their general habits of keeping in bushy localities being sufficient y like its own to admit of this companionship.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
385	♀ jun.	Tejon Mountains, Cal	Aug. 17	H. W. Henshaw	1.90	2.05	0.54	0.73
414	♀	do	Aug. 19	do	1.94	2.18	0.54	0.71
595	♂	Kernville, Cal	Aug. 23	do	2.08	2.20	0.55	0.75
672	♂	Walker's Basin, Cal	Nov. 9	do	1.97	2.12	0.58	0.65
763	♀ jun.	Tejon Mountains, Cal	Aug. 2	do	2.05	2.10	0.58	0.68
764	jun		Aug. —	do	2.12	2.28	0.56	0.73

24. *Troglodytes aëdon*, Vieill., var. *parkmanni*, Aud.—Parkman's Wren.

The most numerous of its tribe in California, inhabiting the wooded sections everywhere.

No.	Sex.	Locality.	Date.	Collector.
80	♂ jun.	Santa Barbara, Cal	June 26	H. W. Henshaw.
314	♂ jun.	Fort Tejon, Cal	Aug. 7	do
463	♂	Near Mount Whitney, Cal	Sept. 10	do
762	jun	California		

25. *Cistothorus palustris*, Wils., var. *paludicola*, Bd.

This Marsh Wren is abundant in Southern California, especially in fall. Though possessed of much the same palustrini habits as in the east, the bird is not nearly so particular here, but will be found to make the most of the circumstances. As tulle swamps and bogs grown up to rushes do not abound, the Wrens often take up their residence on the running streams, where covert is so scanty that their habits necessarily undergo considerable change.

No.	Sex.	Locality.	Date.	Collector.
414	♂	Fort Tejon, Cal	Aug. 19	H. W. Henshaw.

MOTACILLIDÆ.—WAGTAILS.

26. *Anthus ludovicianus*, (Gm.).—Titlark.

The Titlark occurs in California, at least in the southern portion, only as a late fall and winter visitant. It is then distributed over the State at large, moving in small parties here and there, its movement depending solely upon the food-supply. This it gleans from the stubble-fields, from the sandy shores of the rivers, and from the grassy plains.

No.	Sex.	Locality.	Date.	Collector.
584	♂	Near Kernville, Cal	Oct. 20	W. H. Henshaw.
585	♂	do	Oct. 20	Do.

SYLVICOLIDÆ.—WARBLERS.

27. *Helminthophaga celata*, Say.—Orange-crowned Warbler.

This Warbler is a common species in summer in Southern California, and indeed possesses in the West an almost unrestricted range, reaching on the coast from Cape Saint Lucas to the Yukon in Alaska, and being distributed throughout the interior. In Colorado, and the interior generally, it is in summer a bird of the mountains, reaching sometimes above the timber, and making its home in the scanty alpine growth of bushes about the lofty summits.

It is found, too, on the mountains of California (var. *lutescens*, Ridgway), but not at all exclusively. It was the only Warbler I found on the island of Santa Cruz, where it was quite numerous, and breeding in early June. The surface of this island, broken up and diversified by rocky ridges, is covered with a growth of chaparral, often very dense, and forms just the locality which this Warbler delights in. A female which I shot June 10 contained an egg which would have been ready for depositing in a few days.

No.	Sex.	Locality.	Date.	Collector.
17	♂ ad.	Santa Cruz Island, Cal	June 10	H. W. Henshaw.
18	♀ ad.	......do	June 10	Do.
277	♀	Fort Tejon, Cal	Aug. 2	Do.
508	♂	Near Mount Whitney, Cal	Sept. 26	Do.

28. *Dendroica æstiva*, (Gm.).—Yellow Warbler.

A common species about Los Angeles in June. It breeds and is quite numerous through the northern half of the State, being confined entirely to the low districts.

No.	Sex.	Locality.	Date.	Collector.
352	♂ jun.	Fort Tejon, Cal	Aug. 10	H. W. Henshaw.

29. *Dendroica auduboni*, (Towns.).—Audubon's Warbler.

This Warbler does not appear to remain in the mountains of California during the summer, as it does in Colorado and Arizona, but repairs farther north to rear its young. It may yet remain to be detected in the high forests in the northern half of the State.

In the neighborhood of Mount Whitney it was common in September, being then on its way south. The common Yellow-rump (*D. coronata*) has not yet been found in California, though found at the Straits of Ituca in April by Dr. Cooper.

No.	Sex.	Locality.	Date.	Collector.
530	♂	Head Tule River, California	Oct. 7	H. W. Henshaw.
539	♀	Near Mount Whitney, Cal	Oct. 9	Do.
557	♀	Near Thunder Mountain, Cal	Oct. 10	Do.

30. *Dendroica nigrescens*, (Towns.).—Black-throated Gray Warbler.

I found this species common in the mountains, near Fort Tejon, in early August, and think they find here in the pine region their summer haunts. After leaving the Coast range, the species was not seen again, not even in the pineries of the high mountains near Mount Whitney.

No.	Sex.	Locality.	Date.	Collector.
765	♀ pin.	Tejon Mountains, Cal	Aug. 2	H. W. Henshaw.
766	jun.	......do	Aug. 2	Do.
291	♂ jun.	......do	Aug. 3	Do.
292	♂ jun.	......do	Aug. 5	Do.
288	♂ jun.	......do	Aug. 5	Do.
377	♀ ad.	......do	Aug. 3	Do.
411	♀	......do	Aug. 17	Do.
412	♀	......do	Aug. 19	Do.

31. *Dendroica occidentalis*, (Towns.).—Western Warbler.

Concerning the occurrence of this Warbler in California, we have no very extended information. Dr. Cooper cites the capture of a single specimen at Petaluma, and considers the species a very rare one.

A single individual, taken near the head of Tule River in October, was the only one I saw. It probably then uses the Rocky Mountains as a highway in its spring and fall journeyings to and from higher latitudes to breed. It was quite common at Mount Graham, Arizona, in September of 1874, there affecting exclusively the spruce and fir woods.

No.	Sex.	Locality.	Date.	Collector.
537	♂	Head Tule River, Cal	Oct. 9	H. W. Henshaw.

32. *Geothlypis trichas*, (L.).—Maryland Yellowthroat.

Apparently not very common, though distributed pretty evenly over the southern portion of the State. Notes and habits as at the East. The Macgillivray's Warbler (*G. macgillivrayi*) was not detected by us, from which I infer its general rarity in the southern portion of the State. It, however, occurs here, as it is given from several localities by Dr. Cooper; also noted at Nevada City by Mr. Nelson.

No.	Sex.	Locality.	Date.	Collector.
431	♂ jun.	Walker's Basin, Cal	Aug. 28	H. W. Henshaw.
432	♂ jun.	......do	Aug. 28	Do.

33. *Icteria virens*, (L.), var. *longicauda*, (Lawr.).—Long-tailed Chat.

The Chat is wide-spread over Southern California, where, however, we nowhere found it abundant. It inhabits the undergrowth and thickets of the streams, from the friendly shelter of which it rarely ventures forth. It is one of the noisiest of our small birds, and one cannot long remain in the vicinity of a spot inhabited by a pair without being made aware of the fact by their noisy outpourings.

No.	Sex.	Locality.	Date.	Collector.
48	♂ ad.	Santa Barbara, Cal	June 25	H. W. Henshaw.
82	♂ ad.	......do	June 26	Do.
293	♂ jun.	Tejon Mountains, Cal	Aug. 3	Do.

34. *Myiodioctes pusillus*, (Wils.), var. *pileolatus*, (Ridgw.).—Western Blackcap.

While at Los Angeles, the middle of June, I found this little bird not uncommon in the swampy thickets, just the places, in fact, most frequented by it during the migrations. They were in full song, and their short, rather faint ditties were heard as they swept in short flights about the extremities of the branches, snapping up their flying food.

The late date at which they were noted seems to preclude the possibility of their being mere migrants, though this departure from their usual habits is strange enough, when this low altitude be compared with the high mountains they resort to in the interior region.

About the middle of August they became common, moving southward from the breeding-grounds in the far north. The bulk of these, however, are the true *M. pusillus*.

No.	Sex.	Locality.	Date.	Collector.
336	♂ jun.	Fort Tejon, Cal	Aug. 9	H. W. Henshaw.
511	♀ ad.	Near Mount Whitney, Cal	Sept. 26	Do.

HIRUNDINIDÆ.—SWALLOWS.

35. *Progne subis*, (L.).—Purple Martin.

Of apparently not so general distribution in Southern California as throughout the territory of the interior region, occuring, however, in colonies here and there.

36. *Petrochelidon lunifrous*, (Say).—Cliff Swallow.

Occurs over the country at large, being perhaps fully as abundant along the seacoast as in the interior.

37. *Hirundo horreorum*, Barton.—Barn Swallow.

This Swallow is far less numerous than the preceding, though on the coast, at least, it is not rare. On the island of Santa Cruz a few pairs were seen, and still clinging to their primitive mode of living. Their nests were built either in caverns or in the sheltered depressions on the faces of the rocky cliffs.

38. *Tachycineta thalassina*, (Sw.).—Violet-green Swallow.

Along the coast this Swallow is very numerous, resorting, as noted by Dr. Cooper almost exclusively to the oak-groves, where, in the natural knot-holes and the deserted homes of Woodpeckers, it builds its nest. It was abundant in September in the high meadows near the base of Mount Whitney, though whether the species is limited to the Coast-range region in summer, and only occurs in the sierras as a migrant, I am unable to say.

No.	Sex.	Locality.	Date.	Collector.
118	♂ ad.	Santa Barbara, Cal	June 28	H. W. Henshaw.
139	♂ ad.	......do	June 29	Do.
140	♀ ad.	......do	June 29	Do.
465	♂	Near Mount Whitney, Cal	Sept. 10	Do.
754	♂ ad.	Tejon Mountains, Cal	Aug. 2	Do.

39. *Stelgidopteryx serripennis*, (Aud.).—Rough-winged Swallow.

Occurs commonly through Southern California, its distribution being regulated only by the presence or absence of suitable localities. Frequents chiefly the banks of the rivers.

VIREONIDÆ.—VIREOS.

40. *Vireo gilvus*, (Vieill.), var. *swainsoni*, Bd.—Western Warbling Vireo.

Occurs commonly in California, inhabiting the deciduous trees of the low districts, and extending upward on the timbered mountains to at least 10,000 feet.

No.	Sex.	Locality.	Date.	Collector.
130	♂ ad.	Santa Barbara, Cal	June 28	H. W. Henshaw.
289	♀ ad.	Tejon Mountains, Cal	Aug. 3	Do.

41. *Vireo solitarius*, (Wils.).—Solitary Vireo.

Southern California does not appear to be included in the range of this species, except in so far as it occurs there during the migrations. Further north, on the Columbia River, they are, according to Dr. Cooper, common in summer.

No.	Sex.	Locality.	Date.	Collector.
376	♀	Tejon Mountains, Cal	Aug. 17	H. W. Henshaw.

42. *Vireo solitarius*, (Wils.), var. *cassini*.—Cassin's Vireo.

In the mountains, near Fort Tejon, the locality from which the first specimen was obtained, I took a single individual in August. This was the only one seen, and I am

inclined to think that with the preceding species the Cassin's Vireo retires in summer to more northern breeding-grounds.

No.	Sex.	Locality.	Date.	Collector.
376	♀	Tejon Mountains, Cal.	Aug. 17	H. W. Henshaw.

43. *Vireo solitarius*, (Wils.), var. *plumbeus*, Coues.—Western Solitary Vireo.

I procured a single specimen of this Vireo in the mountains near Fort Tejon, August 1. It is in much-worn plumage, and probably had bred in this locality.

The species is, however, one belonging more particularly to the Southern Rocky Mountains.

No.	Sex.	Locality.	Date.	Collector.
767	♀ ad.	Tejon Mountains, Cal.	Aug. 1	H. W. Henshaw.

44. *Vireo pusillus*, Coues.—Least Vireo.

The Least Vireo was the most abundant of its tribe about Los Angeles in June, and their notes, remarkable only for their oddity and quaintness, were constantly heard issuing from the thickets, often several males singing at a time. The bird seems to be the counterpart of the eastern *Vireo belli*. It is never seen in the open, and very rarely in the taller, trees, but keeps within the shelter of the shrubbery, either along a stream or in the swamps. It is very active and restless, and, numerous as they were, I found it very difficult to get even a glimpse of them, as they flitted about, now just over the ground, now in the tops of the young trees, that grew so thickly as to limit my view to the space of a few yards.

As far north as Santa Barbara and Fort Tejon they were quite numerous, and their range will very probably be found to reach as far north as San Francisco.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
24	♂ ad.	Los Angeles, Cal.	June 17	H. W. Henshaw.	2.12	2.25	0.41	0.72
258	♂ jun.	Santa Barbara, Cal.	July 7	....do	2.08	2.22	0.38	0.77
312	♀ jun.	Fort Tejon, Cal.	Aug. 7	....do	2.07	2.05	0.42	0.74
335	....	......do	Aug. 9	....do	2.20	2.14	0.40	0.75

45. *Vireo huttoni*, Cassin.—Hutton's Vireo.

Vireo huttoni, Cassin, Pr. A. N. Sc. Phila. v, Feb., 1851, 150.—Bd., B. N. A., 1858, 339.—Coop., B. Cal., i, 1870, 121.—Coues, Key N. A. B., 1872, 123.—B., B., & R., N. A. B., i, 1874, 387.

This species is one of the least known of all our Vireos; nor is this owing entirely to its rarity, for at Santa Barbara, in June, it was quite common, and according to Dr. Cooper this is true in other parts of California, it wintering plentifully as high as latitude 38°. It breeds, I am inclined to believe, through the whole of Southern California.

In habits it is arboreal, as much so, judging from those I saw, as the Warbling Vireo. It frequented the oaks exclusively, and was at this season entirely silent, so that, though I watched them for the express purpose of listening to their notes, I heard not a single strain. This was probably due to the fact that their broods were just out and required their full attention.

All their movements were marked with a quiet deliberation as they silently moved about the ends of the branches, searching them with the utmost care for food.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
769	♀ ad.	Santa Barbara, Cal.	June 14	H. W. Henshaw.	2.45	2.15	0.43	0.76
58	♂ ad.	......do	June 25	....do	2.43	2.09	0.42	0.75
109	♂ jun.	......do	June 27	....do	2.35	2.10	0.39	0.73
110	♀ ad.	......do	June 27	....do	2.38	2.04	0.43	0.73
111	♂ ad.	......do	June 27	....do	2.29	2.07	0.42	0.76
135	♂ jun.	......do	June 29	....do	2.35	2.04	0.42	0.75
152	♂ jun.	......do	June 29	....do	2.40	2.12	0.43	0.73
245	♀ ad.	......do	July 17	....do	2.45	2.15	0.40	0.72

Ampelidæ.—Chatterers.

46. *Phænopepla nitens*, (Sw.).—Black Flycatcher.

I saw this species on but few occasions. They are, however, not rare in the southern half of the State. They inhabit the bushy cañons, and are found much about the oaks, upon which they find the berries of the mistletoe. In fall these and other kinds of berries form their chief sustenance, varied with insects which they capture on the wing. They are among the shyest of the small birds.

47. *Miadestes townsendi*, (Aud.).—Townsend's Solitaire.

This species probably resorts to the high mountains, as in the interior region, to pass the summer. I saw none till in September; when in the Sierras, they appeared here and there noiselessly pursuing their avocations. Though usually a bird of very unsocial disposition, the abundance of food at any special locality, as berries, attracts them in numbers, when they seem inclined to live more or less in company, and in late fall are apt to be seen in parties of four or five individuals. They never, however, flock, in the strict meaning of the word.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
464	♂	Near Mount Whitney, Cal	Sept. 26	H. W. Henshaw.	4.45	4.24	0.52	0.79
498	♀	......do	Sept. 26	....do	4.49	4.09	0.50	0.82
498 A	♀	......do	Sept. 26	....do	4.59	4.15	0.47	0.83
499	♂	......do	Sept. 26	....do	4.58	4.12	0.48	0.80
500	♂	......do	Sept. 26	....do	4.57	4.18	0.49	0.82
501	♀	......do	Sept. 26	....do	4.55	4.16	0.48	0.82
502	♂	......do	Sept. 26	....do	4.53	4.15	0.47	0.82

Laniidæ.—Shrikes.

48. *Collurio ludovicianus*, (L.), var. *excubitoroides*.—Swain's White-rumped Shrike.

This Shrike is numerous in California, where its habits of life throughout appear not different from its usual mode of existence elsewhere. As noticed by Professor Baird, in his Review, there is observable in the birds from the west coast an appreciable difference from those of the interior, which latter represent what may be called the normal type of coloration of the var. *excubitoroides*. In our specimens from California the ash above is darker, the hoariness of the forehead of less extent, the white of scapulars more restricted. All the specimens, however, taken on the mainland have the white rump clearly defined. In this connection, two young birds in nesting plumage taken on Santa Cruz Island are especially noteworthy. These appear in all respects to be typical *ludovicianus*. In the depth of the plumbeus shade above and along the sides, in the lack of any hoariness on the forehead, and, above all, in the absence of any whiteness of the rump, this being like the back, they exactly resemble young birds from Florida.

No.	Sex.	Locality.	Date.	Collector.
87	♀	Santa Barbara, Cal	June 26	H. W. Henshaw
205	♀ jun.	......do	July 6	Do.
467	♂ jun.	Near Mount Whitney, Cal	....	Do.
750	....	......do	....	Do.
625	♀	Kernville, Cal	Oct. 27	Do.
		Ludovicianus.		
15	♂	Santa Cruz Island, Cal	June 10	Do.
16	♂	......do	June 10	Do.

Tanagridæ.—Tanagers.

49. *Pyranga ludoviciana*, (Wils.).—Louisiana Tanager.

In one of the small cañons issuing from the mountains near Santa Barbara I found several of these Tanagers in July, at which time they were feeding their young. Elsewhere in Southern California they were most unaccountably rare, and, all told, I do not think I saw over a dozen during the entire summer. Probably the bulk of their numbers pass farther north to breed.

FRINGILLIDÆ.—FINCHES.

50. *Carpodacus purpureus*, (Gm.).—Purple Finches.

This species appears to be at least not a common one in Southern California, a single specimen being all obtained or seen by us. Dr. Cooper speaks of finding them on the summits of the Coast range, toward Santa Cruz, in May, where they had nests.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
563	♀	Near Mount Whitney, Cal..	Oct. 10	H. W. Henshaw...	3.00	2.34	0.45	0.72

51. *Carpodacus frontalis*, (Say).—House Finch.

In Southern California, in summer this Finch is perhaps the most numerous of any of the small birds. Their diffusion is very general, the mountains alone being unvisited by them. On the island of Santa Cruz, their numbers are as great as on the mainland. They are always found in greatest numbers in the vicinity of houses, where there are scarcely any bounds to their familiarity. On the uninhabited portions of the island a few had taken up their abode, resorting to little niches in the face of cliffs to place their nests. Their disposition toward each other is sociable in the extreme, and wherever found they will be seen to have established themselves into communities, often of many individuals, while the air is fairly filled with their songs, which continue from morning to night.

No.	Sex.	Locality.	Date.	Collector.
72	♀ ad.	Santa Barbara, Cal	June 26	
73	♂ ad.	......do	June 26	
74	♂ jun.	......do	June 26	
129	♂ ad.	......do	June 28	
150	♂ ad.	......do	June 29	
151	♂ ad.	......do	June 29	
159	♂ ad.	......do	June 29	
160	♂ ad.	......do	July 1	
161	♂ ad.	......do	July 1	
248	♀ ad.	Walker's Basin, Cal	July 1	
342	♀ jun.	Fort Tejon, Cal	July 17	
770	♂ ad.	Santa Barbara, Cal	Aug. 9	

52. *Chrysomitris tristis*, (Linn.).—Goldfinch.

This is an abundant species throughout Southern California, avoiding only the high mountainous districts. It was particularly numerous at Los Angeles, and as early as the middle of June was breeding plentifully. Their eggs at this time were in most cases far advanced toward hatching, though in one instance fresh eggs were found, and in another the nest had been just begun.

In a dense willow-thicket within an area of a few yards no fewer than seven of their nests were counted. They were all placed quite low, the highest about 12 feet from the ground, and, save in being less compactly woven, resembled the usual style of structure in the East. The eggs are of an unspotted greenish-white color.

No.	Sex.	Locality.	Date.	Collector.
26	♀ ad.	Los Angeles, Cal	June 17	H. W. Henshaw.

53. *Chrysomitris psaltria*, (Say.).—Arkansas Finch.

Of the three species inhabiting Southern California, this Goldfinch appears to be the most widely spread, as perhaps also the most numerous. It was seen at many different localities, and, like the other two, inhabits the valleys. The reeds of grasses and weeds appear to form the chief part of its food.

No.	Sex.	Locality.	Date.	Collector.
247	♀ jun.	Ojai Creek, Cal	July 17	H. W. Henshaw.
294	♂ jun.	Fort Tejon, Cal	Aug. 3	Do.
338	♂ ad.	......do	Aug. 9	Do.
338	♂ ad.	......do	Aug. 9	Do.
339	♂ jun.	......do	Aug. 9	Do.
340	Jun.	......do	Aug. 9	Do.
341	♀ jun.	......do	Aug. 9	Do.
344	♀ jun.	......do	Aug. 9	Do.
426	♂ jun.	Walker's Basin, Cal	Aug. 27	Do.
427	♀ ad.	Fort Tejon, Cal	Aug. 28	Do.
430	♂ ad.	Walker's Basin, Cal	Aug. 28	Do.
433	♀ jun.	......do	Aug. 28	Do.
434	♀ jun.	Fort Tejon, Cal	Aug. 28	Do.
435	♀ jun.	......do	Aug. 28	Do.

54. *Chrysomitris lawrencii,* (Cassin).—Lawrence's Goldfinch.

Carduelis lawrencii, Cassin, Proc. A. N. Sc., v, Oct., 1859, 105, pl. v (California).—Heermann, P. R. R. Rep., x, 1859, vi. 50, (California).
Chrysomitris lawrencii, Bd., B. N. A., 1858, 424.—Xantus, Proc. Phila. Acad. Nat. Sci., 1859, 191.—(Ft. Tejon, Cal.).—Coop., B. Cal., i, 1870, 121.—Coues, Key N. A. B.. 1872, 132.—B., B., & R., N. A. B., 1874, 478.

This Goldfinch appears to be more particularly a Californian species, and I do not find it reported from outside the State, except from Camp Whipple, Arizona. Its distribution here seems confined to a comparatively narrow area coastwise, from the southern border to the most northern portions of the State, where Heermann gives it as very abundant throughout the mining-regions. It thus may, and probably does, extend somewhat into Oregon, though it has not been detected at Camp Harney by Lieutenant Bendrie.

Near Santa Barbara, which was the only place where I met with the bird, it was a numerously represented species, though even there my observations respecting it were confined to a single locality, the neighborhood of some springs of fresh water to which the birds resorted in great numbers all through the day to slake their thirst. They certainly did not breed in the immediate locality, and I was at a loss to imagine the particular attraction the spot had for them.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
53	♂ ad.	Santa Barbara, Cal	June 25	H. W. Henshaw	2.53	2.03	0.32	0.50
56	♂ ad.	......do	June 25	....do	2.80	2.24	0.33	0.54
57	♂ ad.	......do	June 25	....do	2.70	2.08	0.35	0.54
75	♂ ad.	......do	June 26	....do	2.79	2.18	0.33	0.53
97	♂ ad.	......do	June 27	....do	2.62	2.16	0.33	0.52
163	♂ ad.	......do	July 1	....do	2.70	2.12	0.32	0.52
164	♂ ad.	......do	July 1	....do	2.73	2.12	0.35	0.52
50	♀ ad.	......do	June 25	....do	2.56	1.97	0.33	0.52
51	♀ ad.	......do	June 25	....do	2.50	2.03	0.34	0.53
165	♀ ad.	......do	July 1	....do	2.54	2.05	0.33	0.47
49	♂ jun.	......do	June 25	....do	2.64			
52	♂ jun.	......do	June 25	....do				
54	♀ jun.	......do	June 25	....do				
55	♀ jun.	......do	June 25	....do				
76	♀ jun.	......do	June 26	....do				
62	♂ jun.	......do	June 25	....do				
98	♀ jun.	......do	June 27	....do				
99	♀ jun.	......do	June 27	....do				
100	♂ jun.	......do	June 27	....do				
176	♂ jun.	......do	July 2	....do				
177	♂ jun.	......do	July 2	....do				

55. *Chrysomitris pinus,* (Wils.).—Pine Finch.

In winter, the Pine Finch overspreads California, probably visiting all portions. It apparently does not, as in the same latitude in the interior, resort to the high mountains in summer, but all retire to the far north. In the interior, about Kernville and elsewhere, it was present the last of October in small flocks, finding in the weed-patches an abundance of food.

No.	Sex.	Locality.	Date.	Collector.
641	♀ jun.	Walker's Basin, Cal	Nov. 5	H. W. Henshaw.

56. *Passerculus savanna*, (Wils.), var. *alaudinus*, Bp.—Western Savanna Sparrow.

We have no positive proof of the occurrence of this variety in California in summer, and all the evidence I could obtain seems to point to the opposite conclusion.

During the fall migrations it makes its appearance from the North, and then occurs over the State at large.

I found it early in September on the streams high up in the mountains, near Mount Whitney, while in November it was exceedingly numerous about Oakland, across the bay from San Francisco, frequenting the plowed lands, gardens, and grassy fields everywhere, almost to the shore. Whether it ever is found in the salt-meadows along the shore I do not know, but believe it never does occur in such places, even during the migrations.

No.	Sex.	Locality.	Date.	Collector.
443	♀	Walker's Basin, Cal	Sept. 6	H. W. Henshaw.
510	♀	North Fork Kern River, Cal	Sept. 29	Do.
587	♀	Near Kernville, Cal	Oct. 20	Do.
588	♂	......do	Oct. 20	Do.
594	♂	......do	Oct. 23	Do.
713	♂	Walker's Basin, Cal	Nov. 11	Do.

57. *Passerculus savanna*, (Wils.), var. *anthinus*.—Fitlark Sparrow.

Passerculus anthinus, Bonaparte, Comptes Rendus, xxvii, Dec., 1853, 919 (Russian America).—Bd., B. N. A., 1858, 445.—Coop, B. Cal., i, 1870, 183.
Passerculus savanna var. *anthinus*, Coues, Key N. A. B., 1872, 136.—B., B., & R., N. A. B., i, 1874, 539.

This sparrow, so far as known, is confined to California,* where it inhabits exclusively the coast, being found in the salt-meadows and beds of rushes. Its habits seem to resemble very closely those of the eastern Savanna Sparrow (*P. savannas*) as seen under similar circumstances. They lie close hidden in the grass, rise with extreme reluctance, and fly with apparent difficulty to a short distance, alighting usually on the tops of the mattocks of grass, or upon the mazing reeds, there to reconnoiter for a moment ere taking refuge among the roots.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
101	♀ jun.	Santa Barbara, Cal	June 27	H. W. Henshaw.	2.57	2.00	0.43	0.80
103	♀ ad.	......do	June 27	....do	2.40	1.90	0.46	0.74
104	♀ ad.	......do	June 27	....do	2.45	1.80	0.46	0.77
105	♂ jun.	......do	June 27	....do	2.65	2.15	0.43	0.79
106	♀ jun.	......do	June 27	....do	2.54	2.00	0.47	0.79
112	♂ ad.	......do	June 27	....do	2.64	2.03	0.47	0.83
119	♀ ad.	......do	June 28	....do	2.40	......	0.40	0.82
120	♂ ad.	......do	June 28	....do	2.56	2.00	0.47	0.82
121	♀ ad.	......do	June 28	....do	2.50	2.00	0.50	0.81
122	♂ ad.	......do	June 28	....do	2.72	2.06	0.47	0.82
156	♀ ad.	......do	July 1	....do	2.43	1.90	0.42	0.77
157	♀ ad.	......do	July 1	....do	2.46	2.00	0.46	0.77
237	♂ ad.	......do	July 8	....do	2.49	2.06	0.46	0.78

58. *Pooecetes gramineus*, (Gm.), var. *confinis*, Bd.—Grass Finch.

I did not meet with the Grass Finch in summer in Southern California, and believe with Dr. Cooper that if it breeds within the State, it is only in the more northern parts. Like the Lark Sparrow, it is more a bird of the dry interior regions, being found, however, over California during the migrations.

No.	Sex.	Locality.	Date.	Collector.
466	♀	Near Mount Whitney, Cal	Sept. 12	H. W. Henshaw.
630	♀	Near Kernville, Cal	Oct. 25	Do.

59. *Coturniculus passerinus*, (Wils.), var. *perpallidus*.—Western Yellow-winged Sparrow.

This Sparrow is chiefly a bird of the interior region, where it is rather southerly in its habitat. It has not hitherto been known certainly to occur on the Pacific coast.

* The locality of Bonaparte's type-specimen was probably transferred with that of *P. alaudinus*. (See B., B., & R., N. A. B.)

At Santa Barbara, directly on the coast, I found the species breeding, and took the young in nesting plumage the last of June. Elsewhere I did not see it, though, as it is a bird of very unobtrusive habits, it may have easily been overlooked; hence its diffusion over Southern California is by no means improbable.

No.	Sex.	Locality.	Date.	Collector.
142	Jun.	Santa Barbara, Cal	June 29	H. W. Henshaw.
162	♀ ad.	......do	July 1	Do.

60. *Chondestes grammaca*, (Say).—Lark Finch.

As might be expected from its almost universal dispersion over the West, the Lark Finch is found in California, wintering, according to Dr. Cooper, in the southern part of the State. That this is somewhat out of their usual range is shown by the fact of their general scarcity as compared with the great number to be seen in the interior sections.

61. *Zonotrichia leucophrys*, (Forst.).—White-crowned Sparrow.

This species is not known to breed in Alaska, or, indeed, within the Pacific coast region. I found it in the high sierras in September, in company with the succeeding variety, forming, however, but a very small proportion of the vast flocks of those birds. In common with some other species, as the *Passerculus alandinus*, large numbers of this Sparrow in pursuing their migration southward in fall, instead of following a direct course, radiate out of the line, and are thus found far to the west and east of the region inhabited by them in summer.

A more notable instance of this irregular mode of migrating is seen in the *Junco oregonus*. This, though a species belonging to the western province, is found in fall and winter diffused over all the interior province, and to the edge of the eastern. In these cases it seems to be merely a question of the abundance of food which determines their path. In a great measure, independent of climatic conditions, the birds wander almost at will, wherever they find their wants most easily satisfied.

No.	Sex.	Locality.	Date.	Collector.
470	♂ ad.	Mount Whitney, Cal	Sept. 12	H. W. Henshaw.
471	♂ ad.	......do	Sept. 12	Do.
491	♀ ad.	......do	Sept. 19	Do.
495	♀ ad.	......do	Sept. 21	Do.

62. *Zonotrichia leucophrys*, (Forst.), var. *intermedia*, Ridgw.

By the middle of September this bird had become very common in the sierras, and at an altitude of 12,000 feet was seen in large flocks feeding among the low willows and alpine shrubbery that fringe the little streams of this elevation. As we descended thence into lower regions, it grew still more abundant, till in the low valleys they numbered thousands. About San Francisco, the middle of November, they were seen in throngs in the shrubbery of the gardens, and they doubtless spend the winter here. This variety does not breed in California.

No.	Sex.	Locality.	Date.	Collector.
478	♂ jun.	Near Mount Whitney, Cal	Sept. 18	H. W. Henshaw.
479	♂ ad.	......do	Sept. 18	Do.
480	♀ jun.	......do	Sept. 19	Do.
481	♂ jun.	......do	Sept. 19	Do.
482	♂ ad.	......do	Sept. 19	Do.
483	♀ ad.	......do	Sept. 19	Do.
484	♀ ad.	......do	Sept. 19	Do.
485	♀ ad.	......do	Sept. 19	Do.
486	♀ jun.	......do	Sept. 21	Do.
492	♂ ad.	......do	Sept. 21	Do.
494	♀ ad.	......do	Sept. 21	Do.
503	♂ ad.	......do	Sept. 26	Do.
549	♀ jun.	Near Kernville, Cal	Sept. 10	Do.
593	♂ jun.	......do	Sept. 23	Do.
575	♂ jun.	......do	Oct. 16	Do.
585A	♂ ad.	......do	Oct. 20	Do.
585	♂ ad.	......do	Oct. 19	Do.
586	♀ jun.	......do	Oct. 20	Do.
660	♂ ad.	Walker's Basin, Cal	Nov. 5	Do.
591	♀ jun.	Near Kernville, Cal	Oct. 23	Do.
592	♂ ad.	......do	Oct. 23	Do.

63. *Zonotrichia gambeli*, (Forst.).—Gambel's Finch.

The true Gambel's Finch is confined to the Pacific province, where it breeds as far to the north as Kodiak. I was unable to detect its presence in the mountains about Fort Tejon in summer, and I am inclined to believe that it does not breed in the sierras south at least of the latitude of San Francisco.

Among a large number of the preceding birds, shot near Mount Whitney in September, were only two of this variety. About San Francisco, too, where in November the other variety was so numerous, I succeeded in finding but a single pair, an adult and a young bird. They are thus probably quite local in their habitat, and resident to a great extent, though in their wanderings for food they extend some distance farther south in the fall and winter than their regular habitat.

No.	Sex.	Locality.	Date.	Collector.
485	♀ ad.	Near Mount Whitney, Cal	Sept. 19	H. W. Henshaw.
486	♀ jun.	......do	Sept. 19	Do.

64. *Zonotrichia coronata*, Pallas.—Golden-crowned Sparrow.

Emberiza coronata, Pallas Zoog. Rosso-Asiat., ii, 1811, 44.
Zonotrichia coronata, Bd., B. N. A., 1858, 461.—Xantus, Proc. Phila. Acad. Nat. Sci., 1859, 191.—Coop. & Suckl., P. R. R. Rep., vol. 12, pt. ii, 1860, 201.—Coop., B. Cal., i, 1870, 197.—B., B., & R., N. A. B., ii, 1874, 573.—Nelson, Proc. Bost. Soc. Nat. Hist., vol. xvii, 359 (California).
Zonotrichia aurocapilla, Newb., P. R. R. Rep., vi, 1857, 88.

In its fall migration, this Sparrow appears to follow pretty exclusively the mountain-ranges, where it is found from their bases up to an altitude of about 6,000 or 7,000 feet, thus avoiding the higher summits and not descending into the valleys. It is a brush-loving species, and inhabits the thickest chaparral of oak-scrub or "blue brush," sometimes in flocks of its own kind, oftener in company with the other *Zonotrichia* and the *Pipilos*. Its habits differ in no noteworthy respect from those of its congeners. Its food, which in the fall consists almost entirely of the seeds of grasses and weeds, is obtained from the ground, the various species mingling together in perfect amity as they conduct their search. By the 10th of November most of the young birds had passed north, those remaining being for the most part in the adult plumage. Later in the fall and in winter their diffusion becomes more general. In company with the var. *intermedia*, they were seen in the hedge-rows and weed-patches about Oakland, where they spend the winter. Probably more or less remain in the mountains of Northern California during the summer. Heerman, as quoted, mentions finding a nest of this species near Sacramento.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
564	♀ ad.	Mountains near Kernville, Cal.	Oct. 16	H. W. Henshaw.	3. 30	3. 37	0. 47	0. 95
568	♂ ad.	......do	Oct. 16	....do	3. 28	3. 45	0. 50	0. 88
668	♂ ad.	Walker's Basin, Cal.	Nov. 9	....do	3. 20	3. 48	0. 50	0. 95
609	♂ ad.	Mountains near Kernville, Cal.	Oct. 25	....do	3. 32	3. 63	0. 46	0. 92
611	♀	......do	Oct. 25	....do	3. 08	3. 17	0. 47	0. 93
561	♂ jun.	......do	Oct. 10	....do	3. 26	3. 40	0. 45	0. 97
565	♂ jun.	......do	Oct. 16	....do	3. 22	3. 37	0. 50	1. 00
566	♀ jun.	......do	Oct. 16	....do	3. 15	3. 25	0. 45	0. 92
565	♂ jun.	......do	Oct. 10	....do	2. 93	3. 05	0. 48	0. 90
603	♀ jun.	......do	Oct. 25	....do	3. 07	3. 25	0. 49	0. 93
604	♀ jun.	......do	Oct. 25	....do	3. 14	3. 33	0. 48	0. 95
567	♀ jun.	......do	Oct. 16	....do	....	......	......	....
605	♀ jun.	......do	Oct. 25	....do	....	......	......	....
607	♀ jun.	......do	Oct. 25	....do	....	......	......	....
608	♂ jun.	......do	Oct. 25	....do	....	......	......	....
715	♀ jun.	......do	Nov. 11	....do	....	......	......	....
540	♀ jun.	Near Whitney, Cal.	Oct. 10	....do	....	......	......	....
610	♂ jun.	Mountains near Kernville, Cal.	Oct. 25	....do	....	......	......	....
618	♀ jun.	......do	Oct. 25	....do	....	......	......	....
614	♂ jun.	......do	Oct. 25	....do	....	......	......	....
612	♀ jun.	......do	Oct. 25	....do	....	......	......	....
613	♂ jun.	......do	Oct. 25	....do	....	......	......	....
615	♂ jun.	......do	Oct. 25	....do	....	......	......	....
616	♀ jun.	......do	Oct. 25	....do	....	......	......	....
617	♂ jun.	......do	Oct. 25	....do	....	......	......	....
569	♂ jun.	......do	Oct. 16	....do	....	......	......	....
619	♂ jun.	......do	Oct. 25	....do	....	......	......	....
695	♂ jun.	Walker's Basin, Cal.	Nov. 11	....do	....	......	......	....
696	♂ jun.	......do	Nov. 10	....do	....	......	......	....
737	Jun.	Mountains near Kernville, Cal.	Oct. 25	....do	....	......	......	....

65. *Junco oregonus*, (Towns.).—Oregon Snowbird.

This Snowbird is probably a summer resident in the high mountains throughout California.

As late as August 19 I obtained the young fully fledged, though still retaining their nest plumage, in the mountains near Fort Tejon, where the species was very abundant. In September the number in the State is increased by the arrival of immense flocks from the north, when they overspread the whole country, remaining till the following spring.

No.	Sex.	Locality.	Date.	Collector.
274	♂ jun.	Mountains near Fort Tejon, Cal	Aug. 2	H W. Henshaw.
275	♀ ad.	......do	Aug. 2	Do.
407	♀ jun.	......do	Aug. 19	Do.
452	♂ ad.	Mountains near Mount Whitney, Cal	Sept. 10	Do.
504	♂ ad.	......do	Sept. 26	Do.
544	♀	......do	Oct. 10	Do.
547	♀ ad.	......do	Oct. 10	Do.
548	♀ ad.	......do	Oct. 10	Do.
556	♀ ad.	......do	Oct. 10	Do.
650	♂ ad.	......do	Nov. 5	Do.

66. *Poospiza belli*, (Cassin).—Bell's Sparrow.

Emberiza belli, Cassin, Pr. A. N. Sc. Phila., v, Oct., 1850, 104, pl. iv, 41 (San Diego, Cal.).
Poospiza belli, Bd., B. N. A., 1858, 470.—Kennerly, P. R. R. Rep., x, 1859, 29.—Heerman, ibid., 46.—Coop., B. Cal., i, 1810, 204.

The Bell's Finch appears to be confined to the southern half of California, where it is a resident species. It inhabits to some extent the chaparral on the mountain-sides, but is more particularly a bird of the sage-brush plains, no spot being too desolate to suit the taste of this Sparrow. In the mountains near Fort Tejon, it breeds abundantly at an elevation of 5,000 or 6,000 feet. At this date, August 4, the young were just moulting and about to don the adult feathering.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
295	♀ jun.	Mountains near Fort Tejon, Cal	Aug. 4	H. W. Henshaw.	2.72	2.96	0.44	0.80
296	♂ jun.	......do	Aug. 4	....do	2.74	2.88	0.38	0.81
297	♂ jun.	......do	Aug. 4	....do	2.82	2.87	0.38	0.82
369	♂ jun.	......do	Aug. 17	....do	2.75	2.91	0.37	0.80
378	♂ jun.	......do	Aug. 7	....do	2.80	2.89	0.39	0.83
390	♂ ad.	......do	Aug. 17	....do	2.75	2.88	0.37	0.81
391	♀	......do	Aug. 18	....do	2.65	2.82	0.39	0.77
392	♀ ad.	......do	Aug. 18	....do	2.63	2.75	0.35	0.74
749	....	......do	....	....do	2.79	2.95	0.43	0.79

67. *Poospiza belli*, (Cassin), var. *navadensis*, Ridgw.—Artemisia Sparrow.

This well-marked variety of the Bell's Finch is found throughout the middle region, being limited in its westward extension by the Sierra Nevada, on the eastern slope of which it was found by Mr. Ridgway.

Though, in the strict meaning of the word, not a migratory species, these Sparrows do yet wander in the fall and winter to very considerable distances. As it is of a hardy nature, these journeyings are undertaken more in quest of food than through the exigencies of climate; though, doubtless, both causes are, to some extent, operative.

It is hence the less surprising that this species should cross the range and be found in the winter on the ground occupied in summer by the other variety alone. At Kernville, I took a single individual, October 28, and saw others.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
636	♂ jun.	Near Kernville, Cal	Oct. 28	H. W. Henshaw	3.13	3.04	0.43	0.86

68. *Spizella socialis*, (Wils.), var. *arizonæ*, Coues.—Western Chipping Sparrow.

According to Dr. Cooper, the Chipping Sparrow is an abundant bird in Northern California, and according to our observations it is pretty well diffused too in the Southern half of the State. The young and old were seen in great numbers in the mountains in the vicinity of Fort Tejon in early August. This species was also seen in June on the island of Santa Cruz.

No.	Sex.	Locality.	Date.	Collector.
141	♂ jun.	Santa Barbara, Cal	June 29	H. W. Henshaw.
269	♂ jun.	Mountains near Fort Tejon, Cal	Aug. 2	Do.
270	♀ jun.	......do	Aug. 2	Do.
271	♀ ad.	......do	Aug. 2	Do.
487	♀ ad.	Mount Whitney, Cal	Sept. 19	Do.

69. *Spizella breweri*, Cass.—Brewer's Sparrow.

Of the distinctness of this species from the *S. pallida* I am well assured, believing that the differences seen in the plumage, which are perfectly appreciable and always constant, the different character of songs and habits, and the totally different habitats of the two are points of distinction too great to be reconciled on the assumption of a mere varietal difference. No intergradation between the two has ever been attempted to be proven, their sameness specifically having apparently been taken for granted on the strength of the superficial resemblance of the two birds.

The mountainous country adjoining Fort Tejon was the only locality where this sparrow was found by our parties. It was here rather numerous in August, and I am inclined to believe that those seen here were summer residents. They perhaps winter in the extreme southern portion of the State.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
413	♂ ad.	Mountains near Fort Tejon, Cal	Aug. 19	H. W. Henshaw.	2. 44	2. 73	0. 33	0. 67
476	♀	......do	Aug. 14	....do	2. 40	......	0. 35	0. 68
772	Jun.	......do	Aug. 14	....do	2. 43	2. 63	0. 34	0. 67

70. *Melospiza melodia*, (Wils.), var. *heermanni*, Bd.—Heerman's Song Sparrow

This Song Sparrow is found all over the southern half of California, and like its allies is, wherever found, an abundant species.

They like best the vicinity of water, and will always be found in the thickets of the small streams, preferring, however, not to follow these upward as they course down from the high mountains, but keep pretty exclusively in the low altitudes. Precisely like their relative in the East, they are always to be seen in the cultivated fields of the farmer, and build even in the hedgerows that surround the houses in the outskirts of the cities. In short, the bird is almost an exact reflection of the Eastern Song Sparrow. Their songs, however, while in general style similar to that bird, are very readily distinguished. Their tones are deeper, the songs longer, and of a much more varied character than the monotonous ditties of the eastern *Melospiza*.

They were quite numerous about San Francisco in November, and I presume they are permanent residents of the same locality throughout the year.

On the borders of Kern Lake, these Sparrows were found in the swamps of Tulle Rushes, their only companions being the Rails and Marsh Wrens.

This was the only *Melospiza* seen by us in the south of the State, and is *par excellence* the Californian Song Sparrow.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
12	♂ ad.	Santa Cruz Island, Cal	June 10	H. W. Henshaw.	2.45	2.62	0.47	0.87
13	♀ ad.	......do	June 10	....do	2.48	2.72	0.46	0.85
14	♂ ad.	......do	June 10	....do	2.37	2.52	0.48	0.83
68	♂ ad.	Santa Barbara, Cal	June 26	....do	2.53	2.70	0.48	0.90
423	♂	Walker's Basin, Cal	Aug. 27	....do	2.43	2.67	0.47	0.84
693	♂ ad.	......do	Nov. 10	....do	2.65	2.97	0.47	0.92
711	♂	......do	Nov. 11	....do	2.56	2.77	0.43	0.85
712	♂	......do	Nov. 11	....do	2.53	2.67	0.43	0.80
59	♀ jun.	Santa Barbara, Cal	June 25	....do	....	......	......	....
59	♀ jun.	......do	June 25	....do	....	......	......	....
60	♀ jun.	......do	June 25	....do	....	......	......	....
61	♂ jun.	......do	June 25	....do	....	......	......	....
69	♀ jun.	......do	June 26	....do	....	......	......	....
77	♀ jun.	......do	June 26	....do	....	......	......	....
107	♂ jun.	......do	June 27	....do	....	......	......	....
145	♂ jun.	......do	June 29	....do	....	......	......	....
155	♂ jun.	......do	June 29	....do	....	......	......	....
357	♂ jun.	Kern Lake, Cal	Aug. 15	....do	....	......	......	....
358	♂ jun.	......do	Aug. 15	....do	....	......	......	....
359	♀ jun.	......do	Aug. 15	....do	....	......	......	....
359 A	♀ jun.	......do	Aug. 15	....do	....	......	......	....
361	♂ jun.	......do	Aug. 15	....do	....	......	......	....
362	♀ jun.	......do	Aug. 15	....do	....	......	......	....
365	♂ jun.	......do	Aug. 15	....do	....	......	......	....

71. *Peucœa ruficeps*, (Cass.).—Red-capped Finch.

I notice this species here merely to call attention to the negative evidence afforded by its entire absence from our collections of the past season. The original specimen came from California, and the species has since been obtained by one or two collectors only, principally by Heerman, who found it abundant near the Calaveras River. Dr. Cooper refers to the species as inhabiting the Catalina Island, where he saw a few. Though I searched carefully for this bird in localities exactly similar to those which were always inhabited by the closely-allied variety (var. *boucardi*) in Arizona, I did not succeed in finding a single individual.

It is certainly not a widely-distributed species, and is probably quite rare. I have recently been informed that Mr. Allen, of Marin County, just north of San Francisco, has found this bird breeding in his locality.

72. *Passerella townsendi*, (Aud.).—Townsend's Sparrow.

Early in October the mountains in the vicinity of Mount Whitney began to be thronged with these birds, strangers from the far north, and now the chaparral and thickets on the steep mountain-sides, as well as the bushy ravines, were crowded by their numbers. From their abundance as far south as Caliente, I should suppose they spread over quite the entire southern part of the State. Lower than an elevation of 5,000 feet I did not find them. In spring they retire to more northern parts to breed, none being known to remain in the State.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.	Depth of bill.
526	♀	Mount Whitney, Cal	Oct. 7	H.W. Henshaw.	3.12	3.05	0.48	0.97	0.38
527	......	Kern River, Cal	Oct. 7	....do	3.17	3.27	0.50	0.90	0.34
534	♂	Mount Whitney, Cal	Oct. 9	....do	3.33	3.22	0.50	0.93	0.36
541	♂	......do	Oct. 10	....do	3.23	3.12	0.50	0.97	0.36
562	♂	......do	Oct. 11	....do	3.19	3.10	0.48	0.93	0.36
644	♀	Walker's Basin, Cal	Nov. 5	....do	3.12	2.95	0.48	0.98	0.37
645	♂	......do	Nov. 5	....do	3.33	3.27	0.50	0.95	0.36
646	♂	......do	Nov. 5	....do	3.28	3.30	0.52	0.95	0.37
665	♀	......do	Nov. 9	....do	3.08	2.98	0.46	0.88	0.34
666	♂	......do	Nov. 9	....do	3.25	3.30	0.50	0.93	0.38
690	♂	......do	Nov. 10	....do	3.10	3.15	0.48	0.93	0.37
691	♂	......do	Nov. 10	....do	3.15	3.16	0.45	0.92	0.33
707	♂	......do	Nov. 11	....do	3.28	3.26	0.51	0.90	0.36
708	♀	......do	Nov. 11	....do	3.30	3.24	0.48	0.93	0.34
709	♂	......do	Nov. 11	....do	3.38	3.29	0.51	1.02	0.39
667	♂	......do	Nov. 9	....do	3.18	3.12	0.48	0.97	0.35

73. *Passerella schistacea*, Baird, var. *megarynchus*, Baird.—Thick-billed Sparrow.

Passerella schistacea, Baird, B. N. A., 1858, 490 (only in part) (Fort Tejon).
Passerella megarynchus, Coop., B. Cal., i, 1870, 221 (Fort Tejon and northward).
Passerella townsendi var. *schistacea*, Coues, Key N. A. B, 1872, 352 (includes this form).
Passerella townsendi var. *megarynchus*, B., B., & R., N. A. B., ii, 1874, 57, pl. 28, f. 10.

Of the four species or varieties of *Passerella*, the present bird is the most remarkable of all. In coloration it approaches, most closely to the form of the northern middle region, *P. schistacea*, from which indeed it differs but little, if color alone be taken as a test. It has the same slate-gray, perhaps slightly darker, as the prevailing tint, contrasted on the wings and upper coverts with brownish rufous. It has associated with an unusual development of the hind claw, an increased size of bill, paralleled perhaps in no other case. This is so thick as to appear actually deformed. In the large series of the preceding bird collected there is no approach to this form in the size of these parts, while the type of coloration peculiar to either is always perfectly tangible and well preserved. Besides being actually larger, the relative proportions of wing and tail are very different. In the present bird, as in the *schistacea*, the tail is very much longer than the wing. In *townsendi* the tail is usually the shorter, sometimes, however, equaling the wing. I have, therefore, thought best to consider *P. schistacea* as distinct from either *townsendi* or *iliacus*, assigning to it as a local variety *megarynchus*, which agrees with it in color and proportions. The relationship of the other two is probably similarly intimate.

The Thick-billed Sparrow appears to be quite confined to California, where it is an exclusive inhabitant of the mountains, chiefly in the middle and southern parts.

Mr. Ridgway found it abundant at Carson City, on the eastern slope of the Sierras, which is the northernmost locality recorded. In the mountains about Fort Tejon it was numerous enough in the month of August, but from its habits it was difficult to become very familiar with it, or even to procure specimens. Besides being of a naturally timid disposition it was only found in the chaparral, which was here composed chiefly of oak scrub; I did not find them lower down than about 5,000 feet.

When found feeding upon the ground on the outskirts of the thickets, they threw themselves with a peculiar loud sharp chirp into the undergrowth, and usually resisted all attempts to dislodge them by keeping in the thickest parts low down among the roots, and only flying, when absolutely compelled, to the next hiding-place.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.	Depth of bill.
371	♂ ad.	Mountains near Tejon, Cal.	Aug. 17	H. W. Henshaw	3.42	3.96	0.63	0.98	0.52
404	♂ ad.	....do	Aug. 19	....do	3.35	3.83	0.64	0.98	0.58
405	♀ jun.	....do	Aug. 19	....do	......	......	......	....	....
290	♂ jun.	....do	Aug. 3	....do	......	......	......	....	....

74. *Guiraca melanocephalus*, (Swains.).—Black-headed Grosbeak.

This species, common throughout the middle region, is no less so on the Pacific slope. It occurs in all portions of California. During the summer it is rather partial to mountainous retreats, where it is found as often in the pine region as elsewhere; but it also graces the lower regions, and is found in the low valleys coming often about the houses.

Its song is the most interesting part of its history, and in its melody this species is excelled by very few others.

No.	Sex.	Locality.	Date.	Collector.
96	♂ ad.	Santa Barbara, Cal	June 27	H. W. Henshaw.
25	♂ jun.	Los Angeles, Cal	June 29	Do.
133	♂ ad.	Santa Barbara, Cal	June 17	Do.

75. *Guiraca cœrulea*, (Linn.).—Blue Grosbeak.

Though quite southern in its distribution, this Grosbeak appears to reach much farther north on the Pacific coast than in the interior, and Dr. Newberry has reported it from the extreme northern part of the State. We met with it at several places in Southern California, where it is pretty well diffused. It is never, I believe, found in the mountains, but inhabits the warm, sheltered valleys.

No.	Sex.	Locality.	Date.	Collector.
28	♀ ad.	Los Angeles, Cal	June 17	H. W. Henshaw.
309	♀ jun.	Fort Tejon, Cal	Aug. 7	Do.
310	♀ jun.	....do	Aug. 7	Do.
332	♀ jun.	....do	Aug. 9	Do.
333	♀ jun.	....do	Aug. 9	Do.
425	♂ jun.	Walker's Basin	Aug. 27	Do.

76. *Cyanospiza amœna*, (Say).—Lazuli Finch.

This Finch, so much like the Indigo-bird in voice and habits, entirely replaces that species in the far west. Its organization seems to unfit it for a residence in high latitudes, and it also shuns the bracing air of the mountains, not occurring, according to Mr. Trippe, higher than 8,000 feet, an altitude at which I have never seen it. It is found in great abundance in the sheltered valleys, living for the most part along the streams, but at any rate the locality chosen must be more or less grown up to brush and bushes, among which it places its nest and spends the greater part of the time.

77. *Pipilo maculatus*, (Swains.), var. *megalonyx*, Bd.—Long-spurred Towhee.

This *Pipilo* is spread in great numbers over the southern half of California, ranging from the shrubbery of the lowlands well up on the mountains. On Santa Cruz Island it was one of the most numerously represented species; indeed, the surface of this island, broken and cut up in every direction by ridges and corresponding ravines, and everywhere covered with chaparral, forms just the abode suited to the habits of this bird. Accordingly, I think I never saw in a limited area such numbers of these birds, their mewing calls sounding in all directions. They are probably resident in Southern California, where, too, their numbers in fall are still further swelled by additions from more inclement regions farther north.

No.	Sex.	Locality.	Date.	Collector.
256	♂ jun.	Fort Tejon, Cal	July 27	H. W. Henshaw.
267	♀ ad.	Tejon Mountains, Cal	Aug. —	Do.
284	♂	......do	Aug. 17	Do.
370	♂ ad.	......do	Aug. 17	Do.
375	♂	......do	Aug. 17	Do.
397	♂ jun.	......do	Aug. 18	Do.
398	♂ jun.	......do	Aug. 19	Do.
406	♂	......do	——— —	Do.
647	♀	Walker's Basin, Cal	Nov. 5	Do.
692	♀	......do	Nov. 10	Do.
743	♂ jun.	Tejon Mountains, Cal	Aug. 2	Do.
744	Jun.	......do	Aug. —	Do.

78. *Pipilo fuscus*, Swains., var. *crissalis*, Ridgw.—Brown Finch.

This Finch was found by our parties in great abundance from San Francisco southward. The appellation Cañon Finch is not a very happy one, since it would suggest a preference for the rocky cañons, an inference by no means borne out by the habits of the bird. It is indeed an inhabitant of the mountains, being there, however, partial to the open thickets on the slopes, rather than to the recesses of the ravines. Moreover, it is found in much greater numbers in the level country and low valleys. In essential particulars it is a true *Pipilo*, having many of the habits common to the birds of this family, but especially resembles the var. *mesoleucus* from the southern interior region, its mode of life being indeed almost identical with that of this bird, except in so far as it has been modified to suit the somewhat different nature of the region it inhabits. It is never found far from cover, though venturing into the open oftener and to a greater distance than is the case with the shyer, more retiring, black *Pipilos*. Its whole nature seems to be more reliant, and in some places I have seen them venturing to the very door of the houses, and hopping with the utmost freedom about the yards, picking up crumbs, in company, perhaps, with their smaller friends, the Snowbirds. Their flight is better sustained and less "jerky" than most of the family, and is not so very unlike that of the Sickle-billed Thrush but that, when taken in connection with its large size, colors, and its long tail, it may often mislead one as it goes flirting through the foliage. When one comes upon them suddenly they throw themselves into the nearest clump with all haste, but should a convenient tree be at hand they will quickly be seen among the branches, where mounting to some convenient perch they sit and watch the cause of all the trouble, the various individuals meanwhile responding

to each others' calls by constant sharp chirps. For birds of this group they are more than usually gregarious. Through the summer each family maintains a close connection. In fall, their wanderings begin, and then they come together in large companies, the numbers being still further augmented by the addition of other species, as the Snowbirds and *Zorotrichias*, the whole forming a merry and united flock. Two broods are reared in a season. At Santa Barbara in June the young were very numerous, while I took the young still in nesting-plumage as late as August 10. I found the species in November about San Francisco, and they doubtless winter here.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
84	♂ jun.	Santa Barbara, Cal	June 26	H. W. Henshaw.				
85	♂ jun.	......do	June 26	....do				
86	♀ jun.	......do	June 26	....do				
128	♂ jun.	......do	June 28	....do				
351	♂ jun.	......do	Aug. 10	....do				
47	♂ ad.	......do	June 25	....do	3.74	4.37	0.60	1.08
422	♂	Walker's Basin, Cal	Aug. 27	....do	3.84	4.68	0.63	1.08
570	♂	Near Kernville, Cal	Oct. 16	....do	4.05	4.95	0.67	1.17
571	♀	......do	Oct. 16	....do	3.55	4.55	0.58	1.04
572	♀	......do	Oct. 16	....do	3.90	4.82	0.63	1.12
634	♂	......do	Oct. 28	....do	3.97	4.83	0.55	1.10
648	♀	Walker's Basin, Cal	Nov. 5	....do	3.67	4.57	0.58	1.07
649	♂	......do	Nov. 5	....do	3.68	4.67	0.58	1.08
710	♀	......do	Nov. 11	....do	3.78	4.52	0.59	1.05

79. *Pipilo chlorurus*, (Towns.).—Green-tailed Finch.

The present bird appears to be by no means as common in Southern California as throughout the interior country. It is pre-eminently a mountain-loving species, and in California I did not find it lower than 5,000 feet. At this elevation it was breeding in the mountains near Fort Tejon; the young, perhaps of a second brood, being taken August 1. It inhabits the tangled brakes and thickets nearly always close to the streams.

No.	Sex.	Locality.	Date.	Collector.
771	♂ jun.	Tejon Mountains, Cal	Aug. 1	H. W. Henshaw.
408	♂	......do	Aug. 19	Do.
409	♂ jun.	......do	Aug. 19	Do.
444	♀	Near Mount Whitney, Cal	Sept. 1	Do.

ALAUDIDÆ.—LARKS.

80. *Eremophila alpestris*, (Forst.), var. *chrysolæma*, Wagl.—Southern Horned Larks.

The small bright-colored race of the Horned Lark is a common summer resident along the coast of Southern California, and is found, too, at this season, according to Dr. Cooper, as far north as Puget Sound. In certain parts of the island of Santa Cruz, it was very numerous in June, as well, too, as along the adjoining shore of the mainland at Santa Barbara. The immense flocks of these birds that gather together in the fall are well known, but I was surprised to find to what extent this sociable feeling was carried during the breeding-season. Both on the mainland and on the island they were seen all through June in scattered flocks of both sexes, though nearly all, perhaps all, were at this time nesting. Both sexes incubate, and it appeared to be the habit of the birds when off duty to repair together in small flocks, and thus to wander in search of food. At this season they do not resort much to the sandy beaches, but keep on the upland, where among the herbage they find more easily, and in greater abundance, the insects and seeds which they are fond of. Their time of breeding must be quite irregular, as I found a fully-fledged young one June 1, though after this I took two nests, with fresh eggs, and the greater number, I am persuaded, still had eggs.

The nests were but rude attempts, being nothing more than a small pile of dried grasses, sufficiently hollowed to admit the reception of the eggs. One is deserving of notice as being placed within the cavity of an "ubalone" shell, one of a large heap, lying half overgrown with herbage. The whole cavity of the shell was filled by the material, and the eggs looked prettily enough as they lay contrasted with the shiny, pearly shells clustered about them. The eggs have a grayish-white background, spotted quite uniformly with fleckings of reddish brown. In one set of these, the background is almost obscured by the markings, which are aggregated together in blotches.

Two sets measured 0.86 × 1.81 — 0.85 × 0.63 — 0.88 × 0.63; 0.80 × 0.63 — 0.80 × 0.63 — 0.77 × 0.62.

ICTERIDÆ.—ORIOLES.

81. *Agelæus phœniceus*, (Linn.), var. *gubernator*, (Wagl.).—Red-shouldered Blackbird.

Psarocolius gubernator, Wagl., Isis, 1832, 281.
Agelaius gubernator, Woodh., Sitgr. Exp., 1853, 89 (California).—Newb., P. R. R. Rep., vi, 1857, 86 (California).—Bd., B. N. A., 1858, 529.—Coop., B., Cal., i, 1870, 263.—Bendire, Proc. Bost. Soc. Nat. Hist., vol. xviii, 1815, 158.
Agelæius phœniceus var. *gubernator*, Coues, Key N. A. B., 1872, 156.—Bd., B., & R., N. A. B., ii, 1874, 163.

Though in perfectly adult plumage easily distinguishable from *phœniceus*, this bird is very closely allied to that species, but may perhaps properly be set apart from it as its western varietal form. It occurs throughout California, being, however, according to Dr. Cooper, chiefly a bird of the warm interior. I saw these birds in but few instances, and had no opportunity to observe their habits, which, however, according to other observers, are quite identical with those of the Eastern Red-wing.

So far as I am aware, no specimens of *A. phœniceus* of unquestioned identity have ever been taken in California, and I am led to believe that this bird does not occur there at all. The immature stages of *A. gubernator* are so much like the corresponding conditions of *phœniceus* that they may readily be mistaken, the one for the other, and in this way *A. phœniceus* has erroneously been ascribed to California.

No.	Sex.	Locality.	Date.	Collector.
31	♂ ad.	Los Angeles, Cal	June 18	H. W. Henshaw.
366	♀ ad.	Fort Tejon, Cal	Aug. 16	....do

82. *Agelæus tricolor*, Nutt.

Icterus tricolor, Nutt. Man., i, 2d ed., 1840, 186.
Agelæus tricolor, Newb., P. R. R. Rep., vi, 1857, 86.—Bd., B. N. A., 1858, 530.—Xantus, Proc. Phila. Acad. Nat. Sci., 1859, 192 (Fort Tejon, Cal.).—Coop., B. Cal., i, 1870, 265.—Bd., B., & R., N. A. B., ii, 1874, 165.
Agelæus phœniceus var. *tricolor*, Coues, Key N. A. B., 1872, 156.

The isolation of this form from its allies seems to be warrantable in view of the tangible differences that distinguish them in all stages, especially when taken in connection with the different habits and notes which most observers have remarked.

The species is quite strictly confined to California, possibly reaching on the north into Southern Oregon. In the southern portion of the State it is resident both on the sea-coast and in the interior. I found the species breeding in but one locality, in Santa Clara Valley, June 21. Noticing large numbers of Blackbirds flying across the road and into an adjoining pasture, I followed their flight till I found myself before a patch of nettles and briers that must have covered three or four acres. The place was not at all swampy, but was a dry pasture, differing in this respect entirely from the breeding-places selected by the Red-wings in the East. I noticed that each bird as it darted down into the clump bore in its bill a large object, which I subsequently found to be grasshoppers. The cause of their journeyings was then explained. They had found some spot where these insects were very numerous, and back and forth they poured all day long, bringing in their bills all they could carry for their hungry young. The nettles grew so dense and high, some attaining to 12 feet, that I found it almost impossible to force my way into their midst, nor did I succeed in penetrating beyond a few yards. I speak within bounds when I say that two hundred pairs had here congregated to rear their young, and the odor arising from some portions was almost as strong as from the Cormorant rookeries. The nests were there by hundreds, nearly every bush holding several. They were, however, mostly old, showing that the place had served for a breeding-resort for probably many years. A few of the nests were this season's and contained young, none that I saw having eggs, though could I have extended my search some would doubtless have been found. The nests were rather slight, flimsy structures, but in general resembled those made by the Red-wing of the East, and were fastened on the bushes in the same way. My presence among them created a great disturbance, and the trees were soon covered with the parent birds, one and all resenting this intrusion on their old-time possessions in no gentle tones. A few days later I came across an immense flock of young birds in the streaked nesting-plumage. Able to take care of themselves, they had gathered thus together, and fairly covered several small trees by the roadside. In all the number there was not a single adult bird. Later still, July 6, a similar flock was found at Santa Barbara, the young having parted from the old birds and made an independent party. Possibly this early separation is due to the fact that the parents, having seen their charges fairly fledged and able to shift for themselves, shook them off and busied themselves with preparations for a second brood.

Heermann notes another very similar breeding-ground in the north of California;

so that it may be the regular habit of the species to thus gather together into rookeries. In fall, the white bordering the Red-wing patch changes to pale buff, being then precisely as seen in southern examples of *A. phœniceus*. The red, however, is of a totally different hue, being many shades darker. The black is of a brilliant metallic luster, very much as in the *Scolecophagus cyanocephalus*, never dull, as in *phœniceus*. The female and young are readily distinguishable from that species.

The Yellow-headed Blackbird is, according to Dr. Cooper, a common resident of the warm valleys of the interior of the State. The species was, however, not met with by us, owing to the fact that scarcely a locality was visited which would meet the necessities of their mode of life.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
33	♂ ad.	Santa Clara Valley, Cal	June 22	H. W. Henshaw.	4.83	3.72	0.92	1.19
34	♂ ad.	do	June 22	do	4.70	3.66	0.92	1.23
35	♂ ad.	do	June 22	do	4.20	3.16	0.75	1.03
37	♂ ad.	do	June 22	do	4.93	3.79	0.92	1.17
363	♂ ad.	do	Aug. 16	do	4.58	3.76	0.86	1.17
364	♂ ad.	do	Aug. 16	do	4.80	3.77	0.88	1.22
626	♂ ad.	do	Oct. 25	do	4.79	3.74	0.90	1.13
745	♂ jun.	do	Aug. —	do	4.58	3.62	0.88	1.23
189	♂ jun.	Santa Barbara, Cal	July 6	do				
190	♀ jun.	do	July 6	do				
191	♂ jun.	do	July 6	do				
192	♂ jun.	do	July 6	do				
193	♂ jun.	do	July 6	do				
194	♂ jun.	do	July 6	do				
195	♀ jun.	do	July 6	do				
196	♀ jun.	do	July 6	do				
197	♀ jun.	do	July 6	do				
198	♀ jun.	do	July 6	do				
199	♂ jun.	do	July 6	do				
200	♂ jun.	do	July 6	do				
201	♀ jun.	do	July 6	do				

83. *Sturnella magna*, (Linn.), var. *neglecta*, Aud.—Western Meadow-lark.

The distribution of the Lark in California agrees with its general dispersion over the West. It is found in the fertile valleys and on the plains, even when the latter are dry. In summer it is more restricted to the meadowy lands where there is herbage sufficient to serve as a cover for its nest. I was much surprised to see a pair upon the island of Santa Cruz, this being about as unpromising a locality for birds of their habits as could well be imagined. The single couple had taken up their abode in a small garden, the green things in which were nourished by a small rivulet of water, and their nest had probably been made in a patch of grain, which they frequented much of the time.

No.	Sex.	Locality.	Date.	Collector.
21	♂ ad.	Santa Cruz Island, Cal	June 10	H. W. Henshaw
172	♂ ad.	Santa Barbara, Cal	July 1	do
173	♀ jun.	do	July 1	do
420	♂	Walker's Basin, Cal	Aug. 27	do
502	♂	Near Mount Whitney, Cal	Sept. 26	do
582	♂ ad.	Near Kernville, Cal	Oct. 21	do
583	♂ ad.	do	Oct. 20	do
628	♂ ad.	do	Oct. 27	do
629	♀	do	Oct. 25	do

84. *Icterus bullocki*, (Swains.).—Bullock's Oriole.

This Oriole occupies in the West the same place so conspicuously filled by the well-known Baltimore in the East. It comes freely into the precincts of village and city, suspending its nest from the swaying limbs of the shadetrees. It was very common about Los Angeles in June, and probably had young at that time.

No.	Sex.	Locality.	Date.	Collector.
260	♀ jun.	Fort Tejon, Cal	Aug. 27	H. W. Henshaw

85. *Scolecophagus cyanocephalus*, (Wagl.).—Brewer's Blackbird.

A very abundant species throughout the State and a constant resident. In summer they prefer the neighborhood of the streams to the marshes proper, though found in the latter in company with the Tri-colored Blackbirds, there existing between the two species an unusually close intimacy. Many of these birds were breeding in company with a large colony of the *A. tricolor* before mentioned.

No.	Sex.	Locality.	Date.	Collector.
320	♀	Fort Tejon, Cal	Aug. 8	H. W. Henshaw
627	♀ ad.	Near Kernville, Cal	Oct. 27	do

CORVIDÆ.—CROWS.

86. *Corvus corax*, Linn., var. *carnivorus*, Baxtr.—American Raven.

The Raven is an abundant resident in California, and is found without much reference to locality. Its omnivorous tastes and its great usefulness as a scavenger are well known. I saw Ravens occasionally on Santa Cruz Island, and, on inquiry, learned that they were no favorites with the sheep-raisers here, on account of their habit of occasionally destroying the lambs. Captain Forney informed me that he had been an eye-witness to the destruction of a lamb by one of these birds, the attack being made first upon the eyes, which were torn out. This habit of the Raven, he states, was well known to the shepherds.

87. *Corvus caurinus*, (Bd.).—Western Fish-Crow.

Corvus caurinus, Bd., B. N. A., 1858, 569.—Coop. & Suckl., P. R. R. Rep., vol. xii, pt. ii. 1860, 211.—Dall & Bann., Tr. Chic. Acad., i, 1869, 286.—Coop., B. Cal., i, 1870, 285.—B., B., & R., N. A. B., ii, 1874, 248.—Bendire, Proc. Bost. Soc. Nat. Hist., vol. xviii, 1876, 159 (Camp Harney, Oreg.).
Corvus americanus var. *caurinus*, Coues, Key N. A. B., 1872, 163.
Corvus ossifragus, Newb., P. R. R. Rep., vi, 1857, 83.

In the uncertainty respecting the relations of this bird, I am disposed to keep it apart from the *Corvus americanus*, with which it has been associated as a variety by some writers, till its relationship be established on a firmer basis than at present. It appears to be mainly distinguishable from its smaller size and certain apparent differences of habits. I regret I can add so little to our knowledge of the subject. On the road from Los Angeles to Santa Barbara, these Crows were seen on several occasions, always in large flocks, and at a distance from the coast of from 5 to 15 miles. In fact, in Southern California, the species does not appear to be specially all maritime in its habits, if, indeed, it is so to more than a moderate extent. In its northern home, however, on Puget Sound and elsewhere, it is essentially a bird of the coast, living there upon shell-fish and the refuse cast up by the waves.

In my own brief experience in California I saw nothing in their manner incompatible with the normal habits of the Common Crow. In this respect, however, it is not different from the Fish-Crow (*ossifragus*) of the Gulf States, which, save in its maritime proclivities, presents little to distinguish its habits from those of the Common Crow; yet the Fish Crow in Florida is found very often miles away from the coast, while not infrequently I have there seen the *Corvus americanus* associated with it in its excursions along shore. The truth seems to be that with birds possessing the omnivorous tastes of the Crows, it is the quantity and ease with which food is obtained that directs their choice more than anything else. Hence, about Puget Sound and this region generally, as in the warm waters of Florida, where mollusks and crustaceans exist in greatest abundance, the habit of resorting to the shores for the chief part of their living has become a fixed one, while elsewhere they find it easier to obtain their food from the interior.

The notes of *caurinus*, as I heard them in California, were different from those of the *Corvus americanus*, and I should say they resemble very closely those of the true Fish Crow. Certainly, no one hearing their hoarse calls could for a moment mistake them for the Common Crow. Like the Fish Crow, the *C. caurinus* keeps very much in flocks, and it is said to even build in communities.

No.	Sex.	Locality.	Date.	Collector.
186	♂ jun.	Santa Barbara, Cal	July 5	H. W. Henshaw.

88. *Picicorvus columbianus*, (Wils.).—Clarke's Nutcracker.

During the month of September, this curious bird was met with in great numbers, and, according to its usual habit, in large flocks in the high sierras, where it kept entirely among the yellow pines. These were hanging full of seeds, and to extract these from the cones was their chief, indeed their only, occupation. Their loud, shrill cries went echoing through the deep woods, as they flew about in noisy bands intent only on cramming their stomachs. The seeds are obtained with much ease and dexterity, as the birds hang back downward, clinging to the ends of the branches or to the cones themselves. A seed fairly extracted, it is taken to a horizontal limb of some size, and there the covering shelled off by a few sharp blows with their heavy bills, when it is quickly disposed of.

The *Gymnokitta cyanocephala* was not noted in any part of the region traversed by the Survey. Though recorded from California, it does not appear to be a common bird on the Pacific slope, and may perhaps be wanting in the more southern parts of the State.

No.	Sex.	Locality.	Date.	Collector.
734	♂	Tejon Mountains, Cal	Aug. 2	H. W. Henshaw.

89. *Pica melanoleuca*, (Linn.), var. *nuttalli*.—Yellow-billed Magpie.

Pica nuttalli, Aud., Orn. Biog., iv, 1838, 450, pl. 362.—Woodh., Sitgr., Exp. Zuñi & Col. Riv., 1854, 77.—Newb., P. R. R. Rep., vi, 1857, 84.—Bd., B. N. A., 1858, 578.—Heerm., P. R. R Rep., x, 1859, pt. vi, 54.—Coop., B. Cal., i, 1870, 295.
Pica melanoleuca var. *nuttalli*, Coues, Key N. A. B., 1872, 164.
Pica caudata var. *nuttalli*, B., B., & R., N. A. B., ii, 1874, 270.

This is the form prevailing in all the region west of the Sierras. They inhabit the valleys, being rather partial to a rough broken surface, interspersed with groves of oaks. I saw many of their nests placed in these. Like their relative from the interior, anything edible suits their appetite, though, like them, flesh is preferred to almost everything else. They are thus, with the Ravens, very useful as scavengers, and, having found the body of a dead animal, never leave the vicinity till the bones and skin alone remain. In the Sierras proper we did not meet with these birds, but in various parts near the sea-coast they were very numerous.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
32	♂ jun.	Santa Clara Valley, Cal	June 22	H. W. Henshaw.	7. 50	9. 50	1. 27	1. 38
36	♂ jun.	......do	June 22	....do	7. 35	8. 15	1. 35	1. 82
134	♀ jun.	Santa Barbara, Cal	June 29	....do	7. 15	8. 65	1. 21	1. 79
182	♀ jun.	......do	July 5	....do	7. 30	9. 50	1. 32	1. 85
183	♀ jun.	......do	July 5	....do	7. 15	8. 30	1. 16	1. 76
184	♂ jun.	......do	July 5	....do				
185	♂ jun.	......do	July 5	....do				

90. *Cyanura stelleri*, (Gm.), var. *frontalis*, Ridgw.—Steller's Jay; Blue-fronted Jay.

Cyanocitta stelleri, Newb., P. R. R. Rep., vi, 1857, 85.—Bd., B. N. A., 1858, 581 (includes var. *frontalis*.)—Xantus, Proc. Phila. Acad. Nat. Sci., 1859, 192.—Coop. & Suckl., P. R. R. Rep., vol. xii, pt. ii, 1860, 215.—Coop., B. Cal., i, 1870, 298 (includes var. *frontalis*).—Coues, Key N. A. B., 1872, 165 (var. *frontalis* also).—Nelson, Proc. Bost. Soc. Nat. Hist., vol. xvii, 360 (California).—Bendire, Proc. Boston Soc. Nat. Hist., vol. xviii, 1875, 160 (Camp Harney, Oregon; probably var. *frontalis*).
Cyanura stelleri var. *frontalis*, B., B., & R., N. A. B., ii, 1874, 279.

This Jay is a common inhabitant of the mountains throughout California, rarely being seen in summer below 5,000 feet, and extending from about that point to the very limit of the timber-line. During the breeding-season, they separate into pairs, and are then very silent and retiring. After the broods are out and well on the wing, they begin their roving, independent life, and their enforced silence gives way to their more usual frame of mind, when noisy outpourings herald their presence in every direction. The bird is a true resident of the pine-woods, and from the pines is had no small part of its subsistence.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
282	Jun.	Tejon Mountains, Cal	Aug. 3	H. W. Henshaw				
421	♂ jun.	Walker's Basin, Cal	Aug. 27	....do				
469	♂ jun.	Near Mount Whitney, Cal	Sept. 12	....do				
461	♀	......do	Sept. 10	....do	5.65	5.25	1.12	1.63
598	♀ ad.	......do	Oct. 16	....do	5.68	5.71	1.28	1.63
599	♀ jun.	......do	Oct. 23	....do	5.58	5.35	1.26	1.43
620	♂ ad.	......do		....do	5.75	5.62	1.33	1.65
621	♂ jun.	Near Kernville, Cal		....do	8.62	5.30	1.36	1.63

91. *Cyanocitta floridana*, (Bartr.), var. *californica*, (Vigors,).—Californian Ground Jay.

Garrulus californicus, Vigors, Zool Beechey's Voy., 1839, 21, pt. v.
Cyanocitta californica, Newb., P. R. R. Rep., vi, 1857, 85.—Bd., B. N. A., 1858, 584.—Xantus, Proc. Phila. Acad. Nat. Sci., 1859, 192; ibid., 1859, 305 (Cape St. Lucas).—Coop., B. Cal., i, 1870, 302.
Aphelocoma floridana var. *californica*, Coues, Key N. A. B., 1872, 166.—Nelson, Proc. Bost. Soc. Nat. Hist., xvii, 1875, 360 (California).
Cyanocitta floridana var. *californica*, B., B., & R., N. A. B., 1874, ii, 291.

So far as habits are concerned, this bird is simply the Florida Jay transferred from the scrub of that peninsula to the chaparral of California. Its vertical range is exactly complementary to that of the Steller's Jay. It is found from well down in the valleys to a height on the mountains of about 5,000 feet, farther up than which it begins to be rare, while here the other, a true Mountain Jay, begins to put in an appearance.

Its mode of life offers little that is distinctive. When disturbed, it clings to the thickets for protection, and if much alarmed makes off at its best speed under their cover. When slightly startled, its curiosity compels it to linger, and in the unfrequented parts of California, and especially upon the island of Santa Cruz, the report of a gun was not sufficient to excite its fears. In this unsophisticated nature, it is rather peculiar; both the Woodhouse s and Florida Jays possessing their full share of the wariness characteristic of the family.

No.	Sex.	Locality.	Date.	Collector.
19	♀ ad.	Santa Cruz Island, Cal	June 10	H. W. Henshaw.
20	♂ ad.	......do	June 11	Do.
731	♀ ad.	......do	June 2	Do.
331	♀ ad.	Fort Tejon, Cal	Aug. 9	Do.
429	♀ ad.	Walker's Basin, Cal	Aug. 28	Do.
656	♂	......do	Nov. 5	Do.
657	♀	......do	Nov. 11	Do.
664	♂	Near Kernville, Cal	Nov. 9	Do.
697	♂	......do	Nov. 10	Do.
698	♂	......do	Nov. 10	Do.
699	♀	......do	Nov. 11	Do.
732	......	......do	Nov. 11	Do.
733	......	......do	Nov. 11	Do.

TYRANNIDÆ.—FLYCATCHERS.

92. *Tyrannus verticalis*, Say.—Arkansas Flycatcher.

This Flycatcher extends from Kansas, and even farther eastward (Iowa), across the central plains, and so on to the Pacific. South it is found well into Arizona, and north into British Columbia. Over much of this region it is abundant, and it is absent only from the high mountain-ranges. In the southern half of California, it is quite numerous, perhaps as much so as anywhere in its wide habitat. Its habits are the same everywhere. The *Tyrannus vociferans*, I find recorded in my note-book as occurring about Los Angeles in June, but I did not secure any specimens, nor was it seen elsewhere.

According to Dr. Cooper, it is quite common in Southern California, and winters about Los Angeles.

No.	Sex.	Locality.	Date.	Collector.
35	♂ ad.	Los Angeles, Cal	June 17	H. W. Henshaw.
88	♀ jun.	Santa Barbara, Cal	June 26	Do.
91	♂ jun.	......do	June 26	Do.
149	♂ jun.	......do	June 29	Do.
268	♂ jun.	Tejon Mountains, Cal	Aug. 2	Do.

93. *Myiarchus cinerascens*, Lawr.—Ash-throated Flycatcher.

Generally distributed over the southern portion of the State and common, avoiding the heavy timber and the mountains. Habits very similar to those of *crinitus*. The young were fully fledged by the middle of July.

No.	Sex.	Locality.	Date.	Collector.
81	♀ ad.	Santa Barbara, Cal	June 26	H. W. Henshaw.
246	♀ jun.	Ojai Creek, Cal	July 17	Do.
261	♂ jun.	Fort Tejon, Cal	July 26	Do.
262	♂ jun.	......do	July 26	Do.
341	♀ jun.	......do	Aug. 9	Do.
279	♀ jun.	......do	Aug. 2	Do.

94. *Sayornis nigricans*, (Swains.).—Black Flycatcher.

This Flycatcher is quite numerous in summer in California, especially in the southern portion, where its habits and method of nidification recall those of the eastern Phœbe.

No.	Sex.	Locality.	Date.	Collector.
43	♂ ad.	Santa Barbara, Cal	June 24	H. W. Henshaw.
143	♀ ad.	......do	June 29	Do.
263	♂ jun.	Fort Tejon, Cal	July 27	Do.

95. *Sayornis sayus*, (Bon.).—Say's Flycatcher.

The proclivity of this species for a rather northerly habitat is seen in California, where it is not found at all in summer in the southern portion, though possibly it occurs in the more northern parts. In the fall, it makes its appearance south of San Francisco late in September, and remains through the winter.

No.	Sex.	Locality.	Date.	Collector.
583	♀	Near Kernville, Cal	Oct. 20	

96. *Contopus borealis*, (Swains.).—Olive-sided Flycatcher.

Coincident with its diffusion over North America generally, this Flycatcher is found on the Pacific coast, though in Southern California at least it appears to be not so numerous as in the middle region. It is pretty closely confined to the mountains.

No.	Sex.	Locality.	Date.	Collector.
753	♂ ad.	Mountains near Fort Tejon, Cal	Aug. 5	H. W. Henshaw.

97. *Contopis virens*, (Linn.), var. *richardsoni*, Swains.—Short-legged Pewee.

In California, as elsewhere throughout the far west, this Pewee is by far the most numerous of the Flycatchers. It is found in every piece of woodland, though in summer the greater number retire to the depths of the mountains.

No.	Sex.	Locality.	Date.	Collector.
144	♀ ad.	Santa Barbara, Cal	June 29	H. W. Henshaw.
321	♀ ad.	Fort Tejon, Cal	Aug. 7	Do.
354	♂ jun.	Tejon Mountains, Cal	Aug. 10	Do.

98. *Empidonax traili*, (Aud.), var. *pusillus*, Swains.—Little Flycatcher.

Dr. Cooper was certainly in error in considering the *E. traili* as identical with the form found in California. This is the same as that occurring in the middle region,

known as var. *pusillus*. Specimens from the two regions are indistinguishable. The habits of the bird in the two regions are quite identical. The bird is an abundant one in Southern California, and especially so in the swampy thickets about Los Angeles.

A nearly-completed nest of this bird, which I found June 17, was placed in a crotch of a swinging grape-vine, and its structure was unusually neat and firm for a Flycatcher. A curious departure from the usual method of nidification has just come to my notice. Mr. Allen, of ———, discovered the nest of this species, with eggs, built in the hollow of a tree. The parent was secured, and its identity thus firmly established.

No.	Sex.	Locality.	Date.	Collector.
27	♂ ad.	Los Angeles, Cal	June 17	H. W. Henshaw.
63	♂ ad.	Santa Barbara, Cal	June 25	Do.
79	♀ ad.	......do	June 26	Do.
310	♂ jun.	Fort Tejon, Cal	Aug. —	Do.
384	♂ ad.	Tejon Mountains, Cal	Aug. 17	Do.

99. *Empidonax flaviventri*, Bd., var. *difficilis*, Bd.—Western Yellow-bellied Flycatcher.

A not uncommon summer resident in Southern California. They spend the summer from sea-level up to 7,000 feet, but are most numerous among the mountains.

No.	Sex.	Locality.	Date.	Collector.
78	♂ ad.	Santa Barbara, Cal	June 26	H. W. Henshaw.
154	♂ ad.	......do	June 29	Do.
410	♂ ad.	Tejon Mountains, Cal	Aug. 19	Do.
415	♀ ad.	......do	Aug. 19	Do.
424	♂ jun.	Near Kernville, Cal	Aug. 27	Do.

100. *Empidonax obscurus*, (Swains.).—Wright's Flycatcher.

I saw but a few of this species in the Sierras, near Mount Whitney, in September. One specimen obtained here was in such immature plumage that I think it had been reared in the neighborhood.

No.	Sex.	Locality.	Date.	Collector.
451	♀ jun.	Near Mount Whitney, Cal	Sept. 10	H. W. Henshaw.

101. *Empidonax hammondi*, (Xantus).—Hammond's Flycatcher.

I could find no evidence that this Flycatcher breeds in Southern California, though I am by no means positive that the deep mountains do not afford it a summer home. Dr. Cooper's account of its method of nidification refers with but little doubt to the var. *pusillus*.

After September, the species became a common one in the mountains. It remains till into October, but finally retires farther south.

No.	Sex.	Locality.	Date.	Collector.
450	♂	Near Mount Whitney, Cal	Sept. 10	H. W. Henshaw.
518	♂	......do	Oct. 3	Do.
551	♀	......do	Oct. 11	Do.

ALCEDINIDÆ.—KINGFISHER.

102. *Ceryle alcyon*, (Linn.).—Belted Kingfisher.

Present here in about the usual numbers. Every small stream which is stocked with fish is occupied by one or more of these birds.

CAPRIMULGIDÆ.—GOATSUCKERS.

103. *Chordeiles popetue*, (Vieill.), var. *henryi*, Cass.—Western Night-hawk.

This Hawk is extremely abundant throughout all of the middle region, but appears to be wanting in much of Southern California. We did not meet with the species at

all; and, with Dr. Cooper, I am inclined to believe that it is wanting through the Coast range. It is spoken of as quite numerous in the Sacramento Valley in summer by Dr. Newberry, and not unlikely occurs in the interior and western portions of the State at this season.

104. *Antrostomus nuttalli*, (Aud.).—Poorwill.

On the summits of the mountains near Fort Tejon the Poorwills were remarkably numerous, keeping hidden during the day among the dense chaparral, where they crouched so close that I several times almost trod on them ere they took to wing.

No.	Sex.	Locality.	Date.	Collector.
751	♂ jun.	Tejon Mountains, Cal	Aug. 2	H. W. Henshaw.
752	♂ jun.	......do	Aug. 2	Do.

105. *Chætura vauxii*, Townsend.—Oregon Swift.

A Swift was present in the Tejon Mountains in August, which I believe was this species.

TROCHILIDÆ.—HUMMING-BIRDS.

106. *Stellula calliope*, (Gould).—Calliope Humming-bird.

This species was most unaccountably rare in the mountains of Southern California, and I saw but a single individual in the Tejon Mountains, August 17. Even this may have been a migrant, and the species may not occur at all in summer in Southern California. It is very abundant in the Cascade Mountains in the northwest, where it breeds.

107. *Trochilus alexandri*, Bourcier & Mulsant.—Black-chinned Humming-bird.

This Hummer was not found by our parties very common in any portion of California. They are probably most numerous in the early part of the season, when flowers are most abundant.

No.	Sex.	Locality.	Date.	Collector.
403	♂ pin.	Tejon Mountains, Cal	Aug. 19	H. W. Henshaw.

108. *Selasphorus rufus*, (Gmel.).—Rufous-backed Humming-bird.

This species is quite common in summer throughout California, and breeds apparently as commonly in the valleys as in the mountains. It occurs at this season all along the coast as far to the north at least as Sitka. A few probably remain during the winter, in the warm, sheltered valleys of the western part of the State, though the species, as a rule, retires farther south for winter-quarters. In comparing a series of these birds taken in California and to the northward with a full *suite* secured by the expedition in Arizona and New Mexico, I was struck with certain differences in coloration which appeared, and though these, after full consideration, appear of too slight and inconstant a nature to warrant the definition of a varietal form upon them, they are yet of sufficient interest as to be worthy of mention. Briefly, the differences resolve themselves into a somewhat deeper tone of coloration in individuals from the Pacific coast. The slight cinnamon of the interior type becomes, in some specimens, a deep rufous, and in all it is noticeably darker. In the male, the flame-colored gorget is tinged strongly with purplish. In them is seen also a tendency to retain the metallic-green color on the dorsal surface, which is common to the females and young, and which, in the interior, is always replaced in the adult males with clear light cinnamon.

In no small proportion of what appear to be adult males from the Pacific coast the metallic green extends from the head entirely over the back and even over the upper tail-coverts, leaving only the tail rufous. Some males, also adult, are found, which have the back of an unmixed rufous, while many occur which exhibit both phases of coloration in varying measure—green mixed with rufous, rufous mixed with green.

As these different conditions may be found in the same locality in California, the impossibility of drawing a varietal line is here seen.

No.	Sex.	Locality.	Date.	Collector.
65	♀ ad.	Santa Barbara, Cal	June 25	H. W. Henshaw.
81	♂ jun.	......do	June 26	Do.
132	♀	......do	June 28	Do.
382	♀ ad.	Tejon Mountains, Cal	Aug. 17	Do.
389	♀	......do	Aug. 18	Do.
774	♂ jun.	......do	Aug. —	Do.
775	♂ jun.	......do	Aug. —	Do.

109. *Calypte anna*, (Lesson).—Anna Humming-bird.

During the summer we saw none of this Hummer in the low valleys, but found it reasonably numerous in the mountains, where it is likely most of them retire to breed. Dr. Cooper, however, found them breeding about San Francisco as early as March. They appear to winter there, as I found them quite numerous in the gardens late in November.

The *Calypte costoe*, according to Dr. Cooper, occurs as far north as San Francisco, where it is rare. None were detected by our parties. Its general distribution is southern, being very abundant in summer at Cape Saint Lucas.

No.	Sex.	Locality.	Date.	Collector.
259	♂ jun.	Fort Tejon, Cal	July 26	H. W. Henshaw.
272	♂ ad.	......do	Aug. 2	Do.
328	♀ ad.	......do	Aug. 8	Do.
381	♀ ad.	Tejon Mountains, Cal	Aug. 17	Do.
387	♂	......do	Aug. 18	Do.
386	♀	......do	Aug. 18	Do.
388	♀	......do	Aug. 18	Do.
401	♂	......do	Aug. 19	Do.
402	♀	......do	Aug. 19	Do.
776	....	California	....	Do.
777	jun.	......do	....	Do.
778	jun.	......do	....	Do.

CUCULIDÆ—CUCKOOS.

110. *Geococcyx californianus*, (Lesson).—Chaparral Cock.

The Ground Cuckoo is an abundant resident through Southern California. It is found in all sorts of localities, though the hill-sides, covered with a more or less dense growth of bushes, and interspersed here and there with rocks, are as well suited to its habits as any. Its food consists of all sorts of insects, of lizards, and the smaller reptiles generally; in fact, of all kinds of animal life that its speed, aided by its powerful bill, enable it to overtake and kill. In many parts of the State, it appears to have become familiarized, to a certain extent, with man, and to regard him with very little fear.

When running at full speed, the long tail is lowered till its end almost touches the ground, when the bird seems fairly to glide over the earth, so easy are its movements. When hurrying, the tail is made of considerable use to enable it to turn quickly, being thrown with a jerk from side to side, according to the direction to be taken. Having gained the cover of the bushes, its safety seems assured, and it usually pauses in the first cover and stands with head erect and listening ears, the tail vibrating with nervous haste, ready to recommence its flight at a moment's warning.

No.	Sex.	Locality.	Date.	Collector.
238	♂ ad.	Santa Barbara, Cal	July 8	H. W. Henshaw.
601	♀	Kernville, Cal	Oct. 25	Do.

PICIDÆ.—WOODPECKERS.

111. *Picus villosus*, (Linn.), var. *harrisi*, Aud.—Harris's Woodpecker.

The Harris's woodpecker is a more or less common summer resident of the mountains throughout Southern California, finding its home chiefly among the pine-forests.

No.	Sex.	Locality.	Date.	Collector.
317	♂ jun.	Fort Tejon, Cal	Aug. 8	H. W. Henshaw.
552	♂ ad.	Near Mount Whitney, Cal	Oct. 11	Do.

112. *Picus pubescens*, (Linn.), var. *gairdneri*, Aud.—Gairdner's Woodpecker.

The disproportion existing in the number of this bird in the interior region, as compared with the preceding species, is not observable in California, at least to anything like the same extent. In Northern California, Cooper appears to have found it not uncommon, and a similar experience was had by us the past season in the region south of San Francisco. In distribution it is not so boreal as the Harris's Woodpecker, and coincident with this difference we do not find it among the high mountains in California, save occasionally, but with the Nuttall's it resorts to the low districts, and frequents, to a great extent, the deciduous timber, especially the oaks.

No.	Sex.	Locality.	Date.	Collector.
126	♂ jun.	Santa Barbara, Cal	July 28	H. W. Henshaw.
138	♀ ad.	......do	June 29	Do.
204	♀ jun.	......do	July 6	Do.
574	♀ jun.	Near Kernville, Cal	Oct. 16	Do.
689	♂ ad.	Walker's Basin, Cal	Nov. 10	Do.
736	♀	......do	....	

113. *Picus nuttalli*, Gambel.—Nuttall's Woodpecker.

Picus nutalli, Gambel, Pr. A. N. Sc., i, 1843, 259 (Los Angeles, Cal.).—Woodh., Sitgr. Exp. Zuñi & Col. River, 1854 (California).—Newb., P. R. R. Rep., vi, 1857, 89.—Bd., B. N. A., 1858, 93.—Xantus, Proc. Phila. Acad. Nat. Sci, 1859, 190.—Coop., B. Cal., i, 1870, 378.—Bd., B., and R., N. A. B., 11, 1874, 521.

Picus scolaris var. *nutalli*, Coues, Key N. A. B., 1872, 193.—Nelson, Proc. Bost. Soc. Nat. Hist., vol. xvii, 1875, 362 (California).

From the *P. scolaris* of the southern interior region and Mexico this bird appears sufficiently distinct. Though in general the two resemble each other, the points of discrepancy are yet sufficiently tangible and are not found to intergrade. The relationship of the *P.* var. *lucasanus* of Cape Saint Lucas seems to be with *scolaris*, and is, I think, to be considered with that bird as distinct from *nuttalli*. Considerable differences exist, I think, in the habits of *scolaris* and *nuttalli*, though in birds like the Woodpeckers, where general family characteristics are to be seen in every species, it is not easy to emphasize these in such manner as to make them very apparent to others, though they may be evident enough in the field.

The notes, especially as I have heard them, differ totally in character. Those of *scolaris* are quite like the usual ones of the well-known *pubescens*. No such similarity can be traced in the *nuttalli*. The usual notes of this species consist of a series of loud, rattling notes, much prolonged, and can be compared with no other Woodpecker with which I am acquainted.

This Woodpecker is a bird particularly of the oak-groves, and ranges from the lower valleys up into the mountains to a height of at least 6,000 feet, where, near Fort Tejon, I found it fairly numerous among the pines; this being the only locality where I found it among the conifers. *P. scolaris*, on the other hand, inhabits the low, hot valleys of the interior, being most partial to the mesquite-thickets. It is never, I believe, at least in Arizona, found in the mountains nor among the pines, and rarely among the oaks, and though I have frequently seen it in places where it would easily have found the surroundings if so minded.

The Nuttall's Woodpecker is pretty strictly confined to California, barely reaching into Oregon on the north, and limited in range eastward by the western slope of the Sierras. It appears to be most numerous in the valleys of the Coast range, though I found it quite common at Fort Tejon, and in October secured specimens at Kernville.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
137	♀ ad.	Santa Barbara, Cal	June 29	H. W. Henshaw.	4.08	2.97	0.80	0.71
136	♂ ad.	......do	June 29	....do	4.07	3.05	0.86	0.75
744	♂ jun.	......do	June 17	....do	4.03	2.79	0.80	0.75
255	♂ ad.	Fort Tejon, Cal	July 27	....do	4.25	....	0.88	0.82
318	♀ jun.	......do	Aug. 8	....do	4.13	2.92	0.78	0.73
349	♂ ad.	......do	Aug. 10	....do	4.08	3.27	0.88	0.73
350	♂ ad.	......do	Aug. 10	....do	4.22	3.20	0.86	0.73
394	♂ jun.	Tejon Mountains, Cal	Aug. 17	....do	....	....	....	....
395	♂ jun.	......do	Aug. 17	....do	....	....	....	....
396	♂ jun.	......do	Aug. 17	....do	....	....	....	....
573	♂ ad.	Near Kernville, Cal	Oct. 16	....do	4.18	2.98	0.82	0.74
589	♂ ad.	......do	Oct. 23	....do	4.10	3.05	0.80	0.73

114. *Picus albolarvatus*, Cassin.—White-headed Woodpecker.

Leuconerpes albolarvatus, Cassin, Pr. A. N. Sc., v, 1850, 106, California.
Picus albolarvatus, Bd., B. N. A., 1858, 96.—Coop. and Suckl., P. R. R. Rep., vol. xii, pt. ii, 1860, 160.—Coop., B. Cal., i, 1870, 382.—Coues, Key N. A. B., 1872, 192.—B., B., and R., N. A. B., ii, 1874, 521.—Nelson, Proc. Bost. Soc. Nat. Hist., vol. xvii, 362 (California).

This fine species was found by us tolerably numerous in the pine-woods of the mountains near Fort Tejon, and also in the Mount Whitney region, and I am inclined to think that it is a resident in the high mountains throughout Southern California. It appears to keep pretty much among the pines, and is thus a bird of the high altitudes. In habits it shows no peculiarities from those of the *Pici* generally, and its notes are in no wise peculiar.

No.	Sex.	Locality.	Date.	Collector.
373	♀ jun.	Tejon Mountains, Cal	Aug. 17	H. W. Henshaw.
545	♀ ad.	Mount Whitney, Cal	Oct. 10	Do.
546	♀ jun.	......do	Oct. 10	Do.
622	♀	......do	Oct. 25	Do.
623	♂ ad.	......do	Oct. 25	Do.
661	♂	Walker's Basin, Cal	Nov. 9	Do.
662	♂	......do	Nov. 9	Do.

115. *Sphyropicus varius*, (Linn.), var. *ruber*.—Red-breasted Woodpecker.

Picus ruber, Gm., Syst. Nat., i, 1788, 429.—Heerm., P. R. R. Rep., x, 1859. pt. vi, 57.
Sphyropicus ruber, Bd., B. N. A., 1858, 104.—Coop. and Suckl., P. R. R. Rep., vol. xii, pt. ii, 1860, 160.—Coues, K. N. A. B., 1872, 195.—Nelson Proc. Bost. Soc. Nat. Hist., vol. xvii, 362.
Sphyropicus ruber, Coop., B. Cal., i, 1870, 392.—Xantus, Proc. Phil. Acad. Nat. Sci., 1859, 190.
Sphyropicus varius var. *ruber*, Bd., B., and R., N. A. B., ii, 1874, 544.

In its typical dress this is purely a Pacific-slope form. It has been shown by Mr. Ridgway to grade gradually into the var. *nuchalis* of the interior, which in Eastern North America gives place to the *varius*, in which the red and black workings are at their minimum.

The Red-breasted Woodpecker is decidedly northern in its distribution, being found in greatest abundance in Oregon and Washington Territory. It breeds about as far south as Fort Tejon, as I took a young bird in the mountains in August, and saw several more. Later, in October, I took a pair near Kernville, though in this extreme southern limit of its range it is rare.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
372	♀ jun.	Tejon Mountains, Cal	Aug. 17	H. W. Henshaw	4.73	3.17	0.96	0.84
637	♂ ad.	Near Kernville, Cal	Oct. 30	....do	4.83	3.35	0.93	0.78
638	♂ ad.	......do	Oct. 28	....do	4.82	3.47	0.93	0.77

116. *Sphyropicus thyroideus*, (Cass.).—Black-breasted Woodpecker; Williamson's Woodpecker.

This Woodpecker was quite common in the heavy pine and red-wood forests in the Sierras, near Mount Whitney, in September, and they doubtless breed here. The males were in about equal numbers with the females, as I have always found them to be in each of the many and widely-separated localities where I have met with the species.

They are among the most silent of the tribe, not only in respect to their notes, but in their manner of procuring food, the most of this being obtained from the crevices of the bark rather than dug out with the noisy hammerings characteristic of many of the family. No other of the tribe is so constant a resident of the conifers as this. It appears to live in them exclusively, and if it ever descends into the lower regions and frequents the deciduous timber it must be only in the depths of winter.

No.	Sex.	Locality.	Date.	Collector.
488	♀ ad.	Near Mount Whitney, Cal	Sept. 19	H. W. Henshaw.
560	♂ ad.	......do	Oct. 11	Do.

117. *Hylotomus pileatus*, (Linn.).—Pileated Woodpecker.

Picus pileatus, Linnæus, Syst. Nat., i, 1766, 173.
Drycopus pileatus, Woodh., Sitgreave's Exp. Zuñi & Col. Riv., 1854, 90 (Indian Territory, Texas, New Mexico.)
Hylotomus pileatus, Bd., B. N. A., 1858, 107.—Coop. & Suckl., P. R. R. Rep., vol. xii, pt. ii, 1860, 161.—Coop., B. Cal., i, 1870, 396.—Coues, Key N. A. B , 1872, 192.—Bd., B., & R , N. A. B.,ii, 1874, 550.—Nelson, Proc. Bost. Soc. Nat. Hist , vol. xvii, 1875, 362 (California).—Bendire, Proc. Bost Soc. Nat. Hist., vol. xviii, 1875, 160 (Camp Harney, Oregon).

This "Log Cock" is found in the Sierras as far south as latitude 37°, where I saw two individuals in October. It is not unlikely that the heavily-timbered districts may give this bird shelter throughout the extent of the Sierras. It was found near Nevada City by Mr. Nelson, but is more numerous farther north, becoming abundant, according to Dr. Cooper, near the Columbia.

118. *Melanerpes torquatus*, (Wils.).—Lewis's Woodpecker.

I did not see this species till reaching Fort Tejon, in August. It was here, and at other places in the Sierras, common in certain localities. In summer, it seems to prefer the pineries of the mountains, but in fall descends, and then inhabits the oak-groves in common with the next species, without, however, mingling with them.

In habits, the species is somewhat anomalous among its relatives. Like the Californian, it is rarely found alone, but associates in bands of many individuals, the gathering taking place as soon as the young are well on the wing. In the late fall, these companies appear to be pretty nearly stationary, not roving over the country at large, but remaining in some favorable spot where food is plenty. Here they may always be found either at play, chasing each other in and out the branches, or industriously hunting for insects. These are obtained with the expenditure of very little labor in digging, as they prefer to take them from the accessible crevices in the bark or even to capture them on the wing. Berries, too, when they can be had, form a part of their varied diet. Their peculiar manner of circling about the tree-tops in wavering circles is well known, and is one of the most noticeable characteristics of its appearance. They are endowed by nature with a shy, suspicious disposition, and always regard the appearance of man with distrust.

No.	Sex.	Locality.	Date.	Collector.
374	♂ juv.	Fort Tejon, Cal	Aug. 17	H. W. Henshaw.
418	♂ juv.	Walker's Basin, Cal	Aug. 27	Do.
419	♂ ad.	......do	Aug. 27	Do.
717	♂ ad.	......do	Nov. 11	Do.

119. *Melanerpes formicivorus*, (Swains.).—Californian Woodpecker.

The habitat of this Woodpecker, in California as in Arizona, seems to be determined by the range of the oaks; the presence or absence of these trees, their abundance or scarcity, affording a pretty sure index of the numbers of this bird. In California, they are certainly the most abundant of the tribe, as they also are in Arizona in the sections they inhabit.

The social instinct is developed in them to a degree equaled in no other species, and they are almost never found other than in large communities, while as often as otherwise they take up their residence in the oaks that overspread the farmers' dwelling. Their most curious trait is seen in their habit, shared by no other Woodpecker, of storing up a supply of acorns in holes drilled for that purpose in the trunks of trees, a custom which seems to admit of no adequate explanation. They were most industriously at this work at Fort Tejon the last of August, and during the day this seemed to keep them busy pretty nearly all the time. Judging from their cries and earnest man-

ner, as they bent themselves to the task of fitting the acorns into the holes, which had served the same purpose the last season, and perhaps many seasons before, the work must be an important one in their own estimation, whatever the object. With them, however, it is not by any means "all work and no play," but, on the contrary, the labor, if labor it be to them, is lightened by much gamboling and chasing each other in and out of the branches in circular sweeps, like boys playing at tag. Indeed, there is no reason why they should not make merry, for food is abundant and easily obtained, not only in the fall, when the acorns are thus laid away, but during all the winter, a fact which serves to make their economy appear all the more inexplicable and useless.

The species is a resident one wherever found.

No.	Sex.	Locality.	Date.	Collector.
300	♀ ad.	Fort Tejon, Cal	Aug. 7	H. W. Henshaw.
301	♂ ad.	......do	Aug. 7	Do.
302	♀	......do	Aug. 7	Do.
316	♂ jun.	......do	Aug. 8	Do.
348	♂ jun.	......do	Aug. 10	Do.

120. *Colaptes mexicanus*, (Swains.).—Red-shafted Flicker.

This Flicker is found throughout Southern California, without reference to special locality, being common both in the mountains and in the low districts. Its habits agree essentially with those of the Common Flicker of the East.

No.	Sex.	Locality.	Date.	Collector.
187	♂ jun.	Santa Barbara, Cal	July 25	H. W. Henshaw.
319	♀ jun.	Fort Tejon, Cal	Aug. 8	Do.
624	♂ ad.	Kernville, Cal	Oct. 25	Do.

STRIGIDÆ.—OWLS.

121. *Strix flammea*, Linn., var. *americana*, (Aud.).—American Barn Owl.

Strix flammea, Linn., Syst. Nat., i, 1766, 133.
Strix americana, Aud., Syn., 1839, 25.
Strix pratincola, Newb., P. R. R. Rep., vi, 1857, 76.—Bd., B. N. A., 1858, 47.—Xantus, Proc. Phil. Acad. Nat. Sci., 1859, 190.—Heerm., P. R. R. Rep., x, 1859, pt. vi, 34.—Coop., B. Cal., i, 1870, 415.
Strix flammea var. *pratincola*, B., B., & R., N. A. B., iii 1874, 13.

The Barn Owl appears to be common throughout Southern California, and in some portions, as in the swamps near Los Angeles and again in the San Bernardino Valley, I found it in great numbers. This was in June, and they had gathered themselves into communities numbering, in one instance, at least twenty. They resorted in the daytime to the dense undergrowth of the swamps or the thickest foliage of the oaks, to doze away in quiet the hours of sunlight. Dusk fairly settling down, they may be seen silently issuing by twos and threes from their shady retreats in quest of food. It becomes less numerous in the northern part of the State, though, according to Dr. Cooper, it is found to the Columbia River.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
29	♂ ad.	Los Angeles, Cal	June 17	H. W. Henshaw.	13.23	5.50	1.33	2.82
773	♀	Santa Barbara, Cal	June 14	....do	13.75	6.00	1.35	2.85

122. *Bubo virginianus*, (Gmel.), var. *arcticus*.—Western Great Horned Owl.

This Owl is found throughout California, confining itself for shelter to the wooded districts. It is a solitary species, the pairs separating as soon as the young are out of the way. Except during the breeding-season, it hunts only by night, though its powers of vision are excellent during the brightest hours of day.

No.	Sex.	Locality.	Date.	Collector.
330	♂	Fort Tejon, Cal	Aug. 8	H. W. Henshaw.

123. *Scops asio*, (Linn.), var. *maccalli*, Cass.—Western Mottled Owl.

The little Screech Owl is a common resident of California, as it is indeed in all the wooded portions of the far west. Its habits, however, are so strictly nocturnal that its presence is easily overlooked.

I have never seen the var. *maccalli* in any but the gray plumage, nor can I ascertain that the red phase of coloration of this variety has been noted by others. The Pigmy Owl (*Glaucidium gnoma*) has been found by several observers to be quite numerous in the mountains of the State. Of the Flammulated Owlet (*Scops flammeola*), a single specimen was taken at Fort Crook. The Whitney's Owl (*Micrathene whitneyi*) occurs in the Colorado Valley, where the type-specimen was shot by Dr. Cooper. The two last may occur over much of the southern portion of the State, but their small size and nocturnal habits render them extremely liable to be overlooked.

No.	Sex.	Locality.	Date.	Collector.
252	♂	Fort Tejon, Cal	July 26	H. W. Henshaw.

124. *Otus vulgaris*, (Linn.), var. *wilsonianus*, (Less.).—Long-eared Owl.

Like the Barn Owl, this species is prone to congregate together, and it is uncommon in the West for one to stumble upon one of these birds roosting in retirement without finding that the same thicket or grove shelters a number. Such was the case at Los Angeles, where the same swamps that gave protection to the Barn Owl also afforded a congenial retreat to this species, and while threading the tangled mazes I several times saw three or four start out from the same spot.

This owl is extremely averse to facing the sunlight, though when forced to do so its eyesight is pretty good.

125. *Speotyto cuniculari*, (Mol.), var. *hypugæa*, (Bon.).—Burrowing Owl.

Nowhere in the West does this Owl occur oftener or in greater numbers than in Southern California, and according to the observations of others it appears to be equally numerous in the northern part of the State.

The deserted holes of the destructive Ground Squirrel (*Spermophilus beecheyi*) furnish it with its usual abode. The birds are very often to be seen during the hours of sunlight sunning themselves at the mouths of the burrows. They are not, however, very active by day, except when disturbed in their meditations, when, with a few expostulatory notes, they fly off a few hundred yards to a neighboring hillock, whence they can keep a good lookout. Their sight under such circumstances is most excellent, and they have no difficulty when so minded in keeping themselves out of danger. Notwithstanding this, I have never seen them in pursuit of food during the day, and should say that this was obtained wholly after nightfall. In the uninhabited districts I have usually found them rather wary, but in the settled parts of California they are quite the reverse, and I have seen them sitting by the roadside paying no attention to the teams and passers-by. It is generally supposed that among other items of their fare are the young of the squirrels. This I have never confirmed, though presuming such to be the case. They are known to eat mice, lizards, and snakes.

FALCONIDÆ—FALCONS.

126. *Falco communis*, Gmel., var. *anatum*, Bon..—Duck Hawk.

This Hawk appears to be rather common in Southern California, being perhaps most so on the coast. It is numerous on the Santa Barbara Islands; also present around Kern Lake, where the water-fowl which reside here throughout the year furnish it with the most of its food.

127. *Falco columbarius*, Linn.—Pigeon Hawk.

At quite a number of localities in Southern California I noted Hawks which appeared to be of this well-known species. The following variety, however, is remarkably close to this species, and hence I may have confounded the two, and a portion of those supposed to belong here may have really been of the next variety, if that be really distinct.

The true Pigeon Hawk is, however, from the observations of others, well distributed over California.

128. *Falco columbarius*, Linn., var. *richardsoni*, Ridgw.—American Merlin.

It does not appear at all certain that this variety, established by Mr. Ridgway, will not be found to be merely a special plumage of the Pigeon Hawk. It was supposed to be confined to the interior region east of the Rocky Mountains. It is, however, found in Southern California, and I think not uncommonly, though I took but a single speci-

men. I frequently saw small Falcons, which I took to be Pigeon Hawks, but at such distances and under such circumstances that I did not succeed in procuring them.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
437	♀ jun.	Walker's Basin, Cal.....	Aug. 28	H. W. Henshaw...	8.30	5.75	0.53	1.48

129. *Falco sparverius*, Linn.—Sparrow Hawk.

In California, as throughout the West generally, the Sparrow Hawk is very numerous. The dry hills along the coast near Santa Barbara were resorted to by great numbers of these birds in July, and in following the line of the telegraph one of them was to be seen perched on one of the poles at intervals of every few yards.

No.	Sex.	Locality.	Date.	Collector.
368	♀	Tejon Mountains, Cal	Aug. 7	H. W. Henshaw.

130. *Pandion haliœtus*, (Linn.), var. *carolinensis*, Gmel.—Fish Hawk.

Present throughout California, both in the interior where the streams are stocked with fish, and on the coast, but more particularly the latter.

131. *Circus cyaneus*, (Linn.), var. *hudsonius*, Linn.—Marsh Hawk.

The open country everywhere is visited by this Hawk, which is very numerous in California. Resident in the southern part.

No.	Sex.	Locality.	Date.	Collector.
596	♂ ad.	Walker's Basin, Cal	Oct. 23	H. W. Henshaw.
597	♀	......do	Oct. 23	Do.
673	♂ ad.	......do	Nov. 9	Do.

132. *Nisus fuscus*, Gmel.—Sharp-shinned Hawk.

A common resident throughout Southern California. This little Hawk is of a bold, dashing disposition, preying indiscriminately upon all the smaller kinds of birds as well as upon small mammals. In procuring these, it beats through the mazes of the woods, following the edges of the thickets, and passing through the leafy openings, and secures its victim, either by surprising and dropping suddenly down upon it, or else, having started it out, pursues it in open chase and clutches it while at full speed.

133. *Nisus cooperi*, (Bon.).—Cooper's Hawk.

The Cooper's Hawk seems to be about as numerous in Southern California as its smaller relative. In summer it is not often seen in the lower districts, but will then be found to have retired to the mountains, where it nests, choosing some lofty pine as the site of its domicile. In the fall, there appears to be a very decided migration from the north, and then the low country generally is occupied by this species, which winters in the southern half of the State.

No.	Sex.	Locality.	Date.	Collector.
383	♀ jun.	Tejon Mountains, Cal....................................	Aug. 17	H. W. Henshaw.
468	♂ jun.	Near Mount Whitney, Cal....................................	Sept. 12	Do.
640	♂ jun.	Walker's Basin, Cal....................................	Nov. 5	Do.

134. *Buteo swainsoni*, Bon.—Swainson's Hawk.

This Hawk appears to be pretty well distributed over the southern part of California, and is, in certain localities, very common. This was the case in the San Fernando Valley in July. Camping here one evening, our attention was directed to the great number of Gophers (*Spermophile hawesii*), which in large colonies inhabited some barren hills near the station. Toward dusk the place was visited by at least a dozen of these birds, which took up their positions on the little hillocks thrown up by the animals in front of their burrows, and awaited with patience the moment when a favorable op-

portunity should occur to snatch a supper. Elsewhere I have frequently seen them thus employed, and their persistence in destroying these pests should entitle them to due consideration at the hands of the farmer. Large numbers of insects, particularly grasshoppers, are destroyed by these birds, whose abilities as purveyors of food are thus of the lowest order.

No.	Sex.	Locality.	Date.	Collector.
740	♂ ad.	Los Angeles, Cal	June —	H. W. Henshaw.

135. *Buteo borealis*, (Gmel.), var. *calurus*, Cassin.—Western Red-tailed Hawk.

The present species is of almost universal distribution in the West, and, though most abundant in the mountains during summer, is by no means confined exclusively to them, but is found more or less commonly in the low country, according to the conveniences it finds for nidification. In California are seen the most extreme examples of the dark fuliginous style of coloration, which is known under the above varietal name. The lighter condition of plumage, which was known to earlier writers as *B. montanus*, is also found, though the proportion of these is not large, and probably it would not be easy to find in California an individual which was not appreciably darker than the usual type of this Hawk from the interior region. On the other hand, the extreme melanistic conditions, in which the rufous markings are only present in slight dashes here and there, and the prevailing color an extreme blackish brown, is also not common. Most individuals range between the two extremes, while no two are exactly alike.

In its wide range, the habits of this Hawk undergo but little change. It is everywhere the same heavy-winged, sluggish bird, its nature causing it to prey upon the very humblest kind of game, and even to eat carrion when this is handiest. In company with the Swainson's Buzzard, it may often be seen in the villages of the Gophers, and like that bird, is more prone to capture these animals by lying in wait for them than by seizing them from above after the manner of the true Hawks.

No.	Sex.	Locality.	Date.	Collector.
477	♂ ad.	Near Mount Whitney, Cal	Sept. 18	
532	♂ ad.	......do	Oct. 7	
576	♂ ad.	Walker's Basin	Oct. 16	
655	♂ ad.	......do	Nov. 5	

136. *Archibuteo ferrugineus*, (Licht.).—Californian Squirrel Hawk.

In my note-book I find reference made to some large Hawks which, in company with the Swainson's, I saw in a Gopher village in the San Fernando Valley in July, and which I believed to be of this species. It does not appear, however, to be at all common in Southern California in summer, but becomes numerous in fall, making its appearance either from the high mountains, or, as is more probable, from farther north. It is more active in its motions and more Falcon-like in its method of hunting than either of the preceding species. It is usually seen beating over the open country on vigorous wing, and keeping a few feet above the ground, ready on the instant to close with any unlucky mammal it may chance to surprise. As implied by its name, it is a determined enemy of the Ground Squirrels, and, with the other two species, must annually destroy an immense number of them. The *A. sanctijohannis* is, according to Dr. Cooper, a winter visitor to the State. I saw in possession of Mr. Gruber, of San Francisco, a fine specimen of this bird, representing the most extreme condition of melanism. It was shot, I believe, near San Francisco.

137. *Elanus Cucurus*, (Vieillot).—Black-shouldered Kite.

This species does not appear to occur in the southern parts of California, where none were met with by our parties. It is found about San Francisco in considerable numbers, and is there a resident.

138. *Haliaëtus leucocephalus*, (Linn.).—White-headed Eagle.

This Eagle is an abundant resident of California, particularly along the sea-coast. It is also not uncommon in the mountain districts. The islands in the Santa Barbara Channel are the resort of many pairs that remain during the year. The broken ledges on the faces of the cliffs, sometimes overhanging the ocean, afford favorite spots for their nests. They are said to annually destroy many of the lambs. I am informed by Lieutenant Carpenter that this Eagle at the mouth of the Columbia River is exceed-

ingly numerous, and that here its habits of feeding upon carrion are as regular and fixed as those of the true Buzzards. Its chief dependence is on fish, more particularly Salmon, of which vast numbers are cast up by the waves. On one occasion, he found half a dozen of these birds feeding upon the flesh of a putrid ox. With this they had become so gorged as to be utterly unable to fly. One of them had so completely filled itself with the foul food that a large piece which it had partially swallowed it was utterly unable to force further down, and in this situation, unable to move, it was approached and knocked on the head with a wiping-stick.

In this region, they nest almost entirely on the tall pines.

CATHARDIDÆ.—AMERICAN VULTURES.

139.—*Pseudogryphus Californianus*, (Shaw).—California Vulture.

Our opportunities for an acquaintance with this Vulture were most brief and unsatisfactory, and were limited to seeing two or three individuals warring on the wing in the mountains. So far as I could learn, they descend rarely into the valleys during the summer months, and only then when attracted by the sight of some dead animal; their keen sight enabling them to detect the presence of food at very long distances. Dr. Taylor informed me that at Santa Barbara they were of quite common occurrence, remaining, however, most of the time in the neighboring mountains. I hear they breed, seeking the shelter of caves, in the most inaccessible situations.

It seems probable that the numbers of this huge bird have very much diminished during the last few years. So large and conspicuous an object could scarcely fail to attract the attention of any chance rover of the wilderness, yet its presence was almost undetected by our parties. As is well known, this bird is easily killed by strychnine, and as this poison has been in almost constant use for a term of years in the destruction of wild animals, it seems highly probable that great numbers of these birds have suffered a like fate from eating the carrion.

According to the observations of earlier naturalists, it was numerous throughout most of California, and extended its range on the north to the Columbia. Near Mount Whitney, in September and October, I frequently saw the carcasses of sheep which had lain for days, and in one instance the body of a huge Grizzly Bear, which had died from poison, was in the final stages of decomposition, yet in no case had any of these been visited by Vultures, a fact which seemed to argue their total absence from this region.

140. *Rhinogryphus aura*, (Linn.).—Red-headed Vulture.

This bird is far more numerous throughout Southern California than its larger relative. It is less of a mountain-loving species, and is, indeed, much less shy and more domestic in its habits, coming freely about the ranches and houses whenever carrion or refuse of any kind is to be had. I saw numbers of them on the islands off Santa Barbara, and think likely they nest there.

COLUMBIDÆ.—PIGEONS.

141. *Columba fasciata*, (Say).—Band-tailed Pigeon.

This Pigeon occurs abundantly in California, retiring to spend the season of reproduction in the mountains, where it resorts very much to the pineries to nest. It does not appear, however, for some cause or other, to be found in any numbers in summer in the more southern portions of the State, and was not seen by us till in the fall, when, in the course of the migrations, it makes its appearance in bands from the far north. In November I often saw them in flocks of from ten to one hundred, flying swiftly about from one oak-grove to another, for, at this season, acorns form their chief, indeed almost their sole, food. Their shyness now is very remarkable, and it is probably due to the fact that in their passage from the north they are compelled to run the gauntlet of hundreds of gunners, who in the neighborhood of cities and towns eagerly pursue them for the market.

142. *Zenaidura carolinensis*, (Linn.).—Carolina Dove.

The Turtle Dove is very numerous in Southern California, its limit northward on this coast being reached at about the forty-ninth parallel, as in other portions of the country.

The dry sandy deserts, which repel nearly all the feathered tribe, form favorite resorts for these Doves. Their powerful wings easily bear them out on the barren wastes, where, it might seem, they would find little to attract them, but where they secure a good supply of seeds from plants whose hardy natures enable them to withstand the drought. The very nature of this dry hard food renders frequent visits to water a necessity, and hence, in the vicinity of any of the rare pools that grace these saharas, the Turtle Dove may always be seen.

TETRAONIDÆ.—GROUSE.

143. *Canace obscurus*, (Say.)—Dusky Grouse.

This Grouse is an inhabitant of high latitudes, but finds in the Rocky and Sierra Nevada Mountains a climate and vegetation analogous to the far northern districts. In California, it is found in both the Coast and Sierra ranges as far south as latitude 35°, and probably even lower. It was present, though not very common, in the mountains near Fort Tejon, and was rather numerous in the region about Mount Whitney. Its presence depends much upon the conifers. It cares less for the pines, but the thick tangled forests of spruce, fir, and tamerack will rarely be entered without grouse sign being very soon apparent. In the Sierras, they are very fond of staying about the vicinity of the little grassy cienagas that are found scattered here and there on the flanks of the mountains, sometimes entirely environed with the coniferous trees.

Lieutenant Carpenter, who has enjoyed most excellent opportunities for observing this bird both in Oregon and the Rocky Mountains, thus speaks of their habits: "Late in the fall, the Dusky Grouse disappear entirely from the grounds frequented by them in summer. At this latter season, their range is much wider. They leave, to a great extent, the thick woods, and are found much in the open glades, where many kinds of berries, as the wild strawberry, afford them a varied and luscious fare. About November, however, they wholly disappear, and a person looking for game in the places where in summer there were an abundance of these birds, would now see no sign of their presence. The idea credited by some, that they have migrated to warmer climes, or that they are passing the long winter hidden away in a torpid state, is alike erroneous. In the Rocky Mountains, about the time of the first heavy snows, they betake themselves to the densest pine-woods, where they live entirely in the conifers. The buds of the pine and spruce now furnish them their only food, and upon these they subsist till the next spring, when the genial sun, with returning warmth, having released the streams and removed the snow, they again descend to mother-earth. In Oregon, too, even along the coast where no snow falls, this same habit obtains. They leave the ground entirely, resort to the pines, and their terrestrial mode of life does not begin till the next summer, when berries and small seeds afford a greater attraction than their usual piny fare. About the 1st of April, the males begin their booming notes, which may now be heard coming from all parts of the forest as the emulous birds begin their courtships. It is at this time that many are shot, the gunners now having a sure guide to their prey in the love-notes, which seem to proceed from the mid-air, as the birds give utterance to them when perched on the branch of some tall pine."

These notes, which are so characteristic of the species in Washington Territory and Orégon, do not appear to have been noticed by any observer in the Rocky Mountains, and Lieutenant Carpenter tells me that not only has he himself not heard this, but all his inquiries among hunters and trappers have failed to establish this habit as belonging to the bird in the various parts of the Rocky Mountains he has visited.

PERDICIDÆ.—QUAILS.

144. *Laphortyx Californicus*, (Shaw).—California Valley Quail.

Tetrao californicus, Shaw, Nat. Miss., pl. 345.
Callipepla californica, Newb., P. R. R. Rep., vi, 1857, 92.—Heerm., ibid., x, 1859, pt. vi, 60.
Lophortyx californica, Bd., B. N. A., 1858, 644.—Xantus, Proc. Phila. Acad. Nat. Sci., 1859, 192.—Bd., Xantus, ibid., 305 (Cape St. Lucas).—Coop. & Suckl., P. R. R. Rep., vol. xii, pt. 11, 1860, 225.—Coop., B. Cal., i, 1870, 549.—Coues, Key N. A. B., 1872, 238.—Nelson, Proc. Bost. Soc. Nat. Hist., vol. xvii, 365 (California).

The Valley Quail, as its name implies, is an inhabitant of the lower districts in California, where it is found overspread over all the country to the west of the Sierra Nevada range. On the north it reaches to the Columbia River. The most extreme limit at which I found it was in the mountains near Fort Tejon, where I saw the species on several occasions at an altitude of 6,000 feet. At this height, I found the young. Here they meet the Mountain Quail, or rather the ranges of the two were found at this point to overlap each other; for the Mountain Quail was found somewhat lower than this. Such, however, is rarely the case, as the Valley Quail is a much less hardy bird than its mountain-loving relative, and courts the warmth of the pleasant valleys. As the number of its natural enemies, in the shape of wild animals and snakes, has been very much diminished through the agency of man, and its increase goes on almost without check, its numbers in some sections of the State are simply enormous. On the island of Santa Cruz, the attempt has been made to introduce them, but with only measurable success, and it is not likely that they will ever there become very numerous; for the number of foxes on this island would be sufficient to keep them in check, were every other condition favorable.

The average time for laying in Southern California seems to be along in April or

early May, and by the last of June large numbers of the young are out and able even to fly short distances. The time, however, for nesting must be quite variable, or else the great disparity in the ages of the broods is due to the fact that the later nestlings are the product of a second clutch of eggs, the first having perhaps been destroyed. Thus, though I have seen many young able to fly in the month of June, I have found others of about the same size and age late in August. Two broods may occasionally be reared in a season.

As soon as the young are out, it is usual for several broods to unite together, and in this way it is not unusual to find in one company birds representing several progressive stages of plumage, and more or less advanced toward maturity. Within the limits of its range, this Quail affects almost all situations. Often during the day, the bands will be found in the vicinity of water, the nature of their food requiring much to soften and aid in its digestion. The bushy pastures, grain fields, and the foot-hills, all in turn invite attention, and are visited by the busy flocks that thus spend the greater part of the day in a constant search for food. Whether it is a constant habit with them to seek shelter during the hottest part of the day, I do not know; but I have often found the bevies about noon in the shade of the bushes that fringe the margin of some favorite spring, where they have come to slake their thirst and apparently pass the heated hours of day in shady seclusion. This I think is a fixed habit with them. In October and November, the young birds are full-grown, and as strong on the wing as their parents.

They now gather into very large bevies, or rather an assemblage of bevies, sometimes a hundred or more, though the average would be less than this. As a rule, their ways are not such as to endear them to the sportsman; for they are apt to be wary, and, unless under specially favorable circumstances, are not wont to lie closely. I have, however, flushed a large bevy contiguous to a bushy pasture where the scrub was about knee-deep, with cattle-paths through it, and have had glorious sport. The birds lay so close as to enable me to walk almost over them, when they got up by twos and threes, and went off in fine style. The sportsman may now and then stumble upon such chances, but they do not come often. A bevy once up, off they go, scattering but little unless badly scared, the main body keeping well together, and having flown a safe distance they drop, but not to hide and be flushed one after another at the leisure of the sportsman. The moment their feet touch firm ground, off they go like frightened deer, and if, as is often the case, they have been flushed near some rocky hill, they will pause not a moment till they have gained its steep sides, up which it would be worse than useless to follow. Should they, however, be put up hard by trees, they will dive in among the foliage and hide, and there standing perfectly motionless will sometimes permit one to approach to the foot of the tree they are lodged in ere taking wing.

They roost always in bushes or trees, and almost invariably in those which are hard by water, which they resort to in the early morning ere setting forth on the business of the day.

When anxious and disturbed, the members of the flock call to each other in querulous tones, the notes resembling the syllable *pit, pit*, constantly repeated; this, too, just as they are taking to wing. Besides this, the males have a loud call, which answers, when the band has been dispersed, to bring them together. This has been variously interpreted. It resembles perhaps as much as anything, when put into English, the words *come-right-here*, the last syllable lengthened and much emphasized.

No.	Sex.	Locality.	Date.	Collector.
83	♂ ad.	Santa Barbara, Cal	June 26	H. W. Henshaw.
92	♂ ad.	......do	June 26	Do.
93	♀ ad.	......do	June 26	Do.
94	♀ ad.	......do	June 27	Do.
116	♂ ad.	......do	June 28	Do.
117	♀ ad.	......do	June 28	Do.
253	♂ ad.	Fort Tejon, Cal	July 26	Do.
254	♂	......do	July 26	Do.
278	jun.	......do	Aug. 2	Do.
578	♂ ad.	Near Kernville, Cal	Oct. 19	Do.
579	♂ ad.	......do	Oct. 19	Do.
580	♀	......do	Oct. 19	Do.
580 A	♀	......do	Oct. 19	Do.
581	♀	......do	Oct. 20	Do.
581 A	♀	......do	Oct. 19	Do.
587	♀	......do	Oct. 20	Do.
588	♀	......do	Oct. 23	Do.
589	♂ ad.	......do	Oct. 23	Do.
653	♂ ad.	Walker's Basin, Cal	Nov. 5	Do.
654	♂	......do	Nov. 5	Do.
716	♂	......do	Nov. 5	Do.
725	jun.	Fort Tejon, Cal	July 26	Do.
726	jun.	......do	July 26	Do.

145. *Oreortyx picta*, Douglas.—Mountain Quail.

Ortyx picta, Dougl., Trans. Linn. Sc., xvi, 1829, 143.
Callipepla picta, Newb., P. R. R. Rep., vi, 1857, 93.—Heerm , ibid, x, 1859, Birds, 61.
Oreortyx pictus, Bd., B. N. A., 1858, 642.—Xantus, Proc. Phila. Acad. Nat. Sci., 1859, 192.—Coop. & Suckl., P. R. R. Rep., vol. xii, pt. ii, 1860, 225.—Coop., B. Cal., i, 1870, 546.—Coues, Key N. A. B., 1872, 237.—B., B., & R., N. A. B., iii, 1874, 475, pl. 63, f. 5.—Nelson, Proc. Bost. Soc. Nat. Hist., vol. xvii, 364 (California).

This, the most beautiful of all our game-birds, is limited in its distribution to California and Oregon, and, as its name well implies, is strictly a bird of the mountains. We found it in the mountains near Fort Tejon, and in the Sierras in a sufficient number of localities as to justify the belief that its distribution in Southern California is at least quite general, and dependent only upon the mountainous nature of the country. In summer, it is not found lower than 4,000 feet, and is not so common at this elevation as somewhat higher. Above 9,000 feet, it was not seen, and this is presumably about its limit. Its habitat is thus complementary to that of the Valley Quail, the higher and lower limits of either species occasionally overlapping each other. It seems nowhere to be an abundant species. As compared with the preceding, the bevies are very small, and I do not remember to have ever seen more than fifteen together, oftener less. It is a wild, timid bird, haunting the thick chaparral-thickets, and rarely coming into the opening. When a band is surprised, they are not easily forced on the wing, but will endeavor to find safety by running and taking refuge in the thickness and impenetrability of their favorite thickets. If forced, however, they rise vigorously and fly swiftly and well, and sometimes to a considerable distance, and then make good their escape by running. During the heat of midday, they will be found reposing under the thick shade of the chaparral, and there they remain till the cooler hours invite them to continue their quest for food. When the covey has been scattered, the males have a loud call, which consists of a series of notes clearly given, the whole recalling to mind the notes of the Golden Flicker. Besides this, both sexes have the more commonly heard piping-notes, which they emit just as they take to wing, and when they are agitated, or moved by fear.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
283	♂ ad.	Mountains near Fort Tejon, Cal	Aug. 3	H. W. Henshaw	5.50	3.70	0.60	1.41
417	♂	......do	Aug. 19	....do	5.25	3.65	0.57	1.47
724	♀ ad.	......do	Aug. 1	....do	5.30	3.43	0.60	1.40
723	....	......do	Aug. 1	....do	5.40	3.27	0.62	1.37
780	♀ ad.	......do	Aug. 1	....do	5.25	3.45	0.57	1.45
779	♀ ad.	......do	Aug. 1	....do	....	......	......	....
640	♂ ad.	Walker's Basin, Cal	Nov. 5	....do	5.43	3.77	0.58	1.48
700	♂	......do	Nov. 5	....do	5.43	3.53	0.58	1.47
701	ad.	......do	Nov. 5	....do	....	......	......	....
702	♂ ad.	......do	Nov. 5	....do	....	......	......	....

CHARADRIIDÆ.—PLOVERS.

146. *Ægialitis vocifera*, (Linn.).—Killdeer Plover.

By the side of every lake and along all the streams, as well as on the shores of California, this Plover is found in great abundance. It is only partially migratory, numbers remaining in Southern California till the ensuing spring sends them farther north.
The Mountain Plover (*A. montana*) occurs and is numerous in certain localities in Southern California, as on the plains about Los Angeles.

No.	Sex.	Locality.	Date.	Collector.
671	♀ jun.	Walker's Basin, Cal	Nov. 9	H. W. Henshaw.

Charadonis cantianus, Lath., Birds, vol. viii, 328 —Heerm., P. R. R. Rep., x. 1859, pt. vi, 64.
Ægilitis (Leucopolius) nivosa, Cass., Bd., B. N. A., 1858, 696.—Coues, 1866, 274 (San Pedro, Cal.).
Ægilitus cantianus, Coues, Key, 1872, 245.

147. *Ægialitis cantianus*, Lath., var. *nivosa*, (Cass.).—Snowy Plover.

This species is an abundant one on the coast of California, though by no means a strictly coastwise bird. I did not see it in the interior, though Mr. Ridgway found the species at Great Salt Lake, where it was breeding. At Santa Barbara, it was numerous, frequenting here only the sandy shores, not following the creeks inland, and never

visiting the marshes, though within a few yards of its breeding-ground. Its habits seemed exactly like those of the common Piping Plover, and their notes are very similar. Its food consists of all sorts of worms and marine crustacea which it finds close to the water's edge, following the retreating waves down and scurrying back as they come rolling in.

July 7, I found two broods of young which had left the nest but a few hours before. They were clothed in down, and were yet so weak as scarcely to be able to stand. Subsequently I found quite a number of nests containing eggs. The spot selected for a breeding-ground was a strip of bare white sand, a hundred yards, perhaps, from the ocean. The nest was simplicity itself. In all but one instance the eggs were deposited in a slight hollow scratched in the sand, without lining of any sort. In the exceptional case the owners must have been of an artistic turn of mind, for they had selected from along the shore little bits of the pearly nacre, the remnants of broken sea-shells, and upon a smooth lining of this material were placed their treasures. The effect of the richly-colored eggs as they lay on the cushion of shining nacre was very pleasing. So slight is the contrast between the eggs and the drifted sand about them that they would be difficult enough to find were it not for the tracks about the nest. As the mates came to relieve each other from setting or to bring each other food, they alighted near the nest, and thus for a little distance about each one was a series of tracks converging to a common center, which too surely betrayed their secret. Great was the alarm of the colony as soon as my presence was known, and, gathering into little knots, they nervously attended my steps, following at a distance with low sorrowful cries. The female, when she found her nest was really discovered, hesitated not to fly close by, and used all the arts which birds of this kind know so well how to employ on like occasions. With wings drooping and trailing on the sand, she would move in front till my attention was secured, when she would fall helplessly down, and burying her breast in the soft sand, present the very picture of utter helplessness, while the male with the neighboring pairs expressed his sympathy with loud cries. The full nest complement appears to be three, and in no instance did I find more. These are of a light clay-color, numerously marked with blotches and scratchy markings of black. In size and appearance they approach most closely to those of *A. melodus*, but may be easily distinguished by the different style of the spotting.

Examining a good series of the eggs of *melodus* in the Smithsonian, I find them to vary among themselves but little in the character of their markings. These take the form of small circular dots, very rarely becoming aggregated into blotches, and without pen-like scratchings. Those of *nivosus* are more heavily marked with irregular blotches, while the scratchy marks are conspicuous. Three sets measure, respectively, 1.30 by 0.93; 1.27 by 0.92; 1.25 by 0.93; 1.29 by 0.93; 1.27 by 0.89; 1.24 by 0.95; 1.22 by 0.90.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
178	♂ ad.	Santa Barbara, Cal	July 4	H. W. Henshaw.	4.23	1.93	0.60	0.97
179	♂ ad.	do	July 4	do	4.22	2.00	0.64	0.92
180	♂ ad.	do	July 4	do	4.20	1.98	0.62	0.98
181	♀ ad.	do	July 4	do	4.08	1.85	0.61	6.88
209	♂ ad.	do	July 7	do	4.02	1.98	0.64	0.96
210	♂ ad.	do	July 4	do	4.08	2.08	0.63	0.92
212	♂ ad.	do	July 7	do	3.90	1.92	0.59	0.92
214	♀ ad.	do	July 7	do	4.20	1.97	0.60	0.92
216	♀ ad.	do	July 7	do	4.13	1.96	0.63	0.98
217	♀ ad.	do	July 7	do	4.13	2.03	0.63	0.93
213	♂ ad.	do	July 7	do				
215	♂ ad.	do	July 7	do				
218	♂ ad.	do	July 7	do				
219	♂ ad.	do	July 7	do				
230	♂ ad.	do	July 8	do				
232	♀ ad.	do	July 8	do				
233	♂ ad.	do	July 8	do				
234	♀ ad.	do	July 8	do				
235	♀ ad.	do	July 8	do				
236	♂ ad.	do	July 8	do				
237	♂ ad.	do	July 8	do				
220	♀ jun.	do	July 8	do				
760	jun.	do	July 8	do				
761	jun.	do	July 8	do				

HÆMATOPIDÆ.—OYSTER-CATCHERS.

148.—*Hæmatopis niger*, Pallas.—Black Oyster-catcher.

Hæmatopis niger, Pallas, Zoog. Rosso-Asiat., ii, 1811, 131.—Towns., Narr., 1839, 348.—Cass., Bd. B. N. A., 1854, 760.—Coop. & Suckl., P. R. R. Rep., xii, pt. ii, 1860, 233.—Coues, Key N. A. B. 1872, 246.

Hæmatopis townsendii, Heerm., P. R. R. Rep., 1859, 65.

This curious bird is found in considerable numbers on the island of Santa Cruz, and, as I was informed, on the others of the group. They much of the time frequented the little islets which were separated from the main islands by narrow channels, probably finding on them breeding-grounds safe from the intrusion of all enemies. Their short, extremely stout legs and feet would seem to adapt them for a life among the rocks, and they probably do obtain much of their food among the kelp and sea-weed that covers the slippery rocks and shelters all sorts of crustaceans and mollusks. The long, strong, wedge-like bill is admirably adapted for the purpose of prying open the bivalve shells. On the island, however, they seemed to obtain a plenteous supply of food by a much easier and readier method, and did not resort to this mode at all. They fed much of the time on the sandy beaches piso, where the Sand-pipers, had there been any, would have resorted, and, like them, found all they wanted on the surface, where it was cast up by the waves. Their stout robust form would not seem to indicate much agility, and their movements were rather clumsy, as though they felt a little out of place. On the level beaches, they were quickest when they followed the retreating waves to the lowest point, whence they would have time to snatch a titbit and run back in season to avoid the on-coming surf. The birds were not at all shy, and would permit me to approach easily enough within 30 yards of them as they rambled along the beach, pausing now and then, and looking back as if not quite assured of my intentions.

Of all the feathered tribe that frequented the island, they were the noisiest, and their harsh vociferous cries could be heard all day long, coming from their island strongholds.

After some search, I succeeded in finding two nests: the first containing a single freshly laid egg was taken June 6, on the extreme point of a high cliff jutting over the sea; the second, a few days later, was found on one of the islets adverted to. The nests proper were rude enough affairs, being simply slight hollows made in the pebbly detritus, which in each case had been added to by bits of stone brought from elsewhere. In neither case was there any grass or other lining softer than the stones themselves. The two eggs in one case were slightly incubated, and probably were all that would have been laid. These are indistinguishable from those of the better known species *H. palliatus*. Their ground-color is a faint, grayish drab, profusely spattered with irregular blotches of black. They measure 2.27 by 1.59; 2.29 by 1.48; 2.18 by 1.52.

The Surf-bird (*Aphriza virgata*) was not found by us on the island of Santa Cruz, and I do not think it breeds on this group. Heermann mentions finding numbers on the Farallone Islands in June, and here it is likely it remains all summer. Mr. Gruber showed me a fine specimen which he obtained at Santa Barbara in spring. It seems to be a rather uncommon species on the Californian coast, and one whose habits are very little known.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
8	♀ ad.	Santa Cruz Island, Cal........	June 4	H. W. Henshaw.	9.75	4.73	3.00	2.03
727	♀ ad.	......do	June 4	....do	10.25	5.03	3.12	2.12
728	♂ ad.	......do	June 4	....do	9.50	4.70	2.73	1.87
729	♂ ad.	......do	June 5	....do	10.15	4.83	2.88	2.05
730	♀ ad.	......do	June 5	....do	10.50	5.02	2.75	2.04

149. *Strepsilas melanacephalus*, Vigors.—Black Turnstone.

This bird occurs on the islands, and all along the coast of California, during the spring and fall migrations. All pass to high northern latitudes to breed.

The *S. interpres* also occurs along the coast.

RECURVIROSTRIDÆ.—AVOCETS; STILTS.

150. *Recurvirostra americana*, Gmel.—American Avocet.

The Avocet occurs in California, though not, I think, in such extreme abundance as in many sections in the interior. On the island of Santa Cruz I saw several, and these had paired, and were probably breeding. As there were no ponds they were driven to

a different mode of life from their usual one, and lived on the beaches, picking up sea-slugs and small crustaceans from the surface. They were present near Los Angeles in June, and apparently on their return journey from more northern parts had stopped in quite large flocks at Kern Lake, where it is possible some may remain all summer.

No.	Sex.	Locality.	Date.	Collector.
738	Ad.	Santa Cruz Island, Cal	June 10	H. W. Henshaw.
739	Ad.	......do	June 10	Do.

151. *Himantopus nigricollis*, Vieill.—Black-necked Stilt.

The Stilt was present in large numbers on the borders of Kern Lake August 15. Usually when I have found these two birds together, the Avocets have far outnumbered the Stilts. Here the case was reversed, and the number of the latter species was largely in excess of any other bird found here.

No.	Sex.	Locality.	Date.	Collector.
355	♂ jun.	Kern Lake, Cal	Aug. 15	H. W. Henshaw.

PHALAROPHIDÆ.—PHALAROPES.

152. *Lobipes Hyperboreus*, (L.).—Northern Phalarope.

This Phalarope is numerous along the coast in Washington Territory, and probably also in California during the migrations. I shot a single one, evidently a wanderer, on a small meadowy mountain-stream in the Sierra Nevada September 15, at an elevation of about 9,000 feet.

No.	Sex.	Locality.	Date.	Collector.
473	♂	Head of Kern River, Cal	Sept. 15	H. W. Henshaw.

SCOLOPACIDÆ.—SNIPES.

153. *Gallinago Wilsoni*, (Temm.).—Wilson's Snipe.

This Snipe is very abundant in all localities suited to its wants during the migrations, and probably more or less winter in the southern part of the State.

154. *Macrorhamphus griseus*, (Gmel.).—Red-breasted Snipe.

During the migrations, occurring in large flocks along the coast, and also on the lakes and ponds in the interior of the State. Present in numbers at Kern Lake in August.

155. *Ereunetes pusillus*, (Linn.).—Semi-palmated Sandpiper.

I saw a small flock of these "Pups" on the sea-shore near Santa Barbara, in July. Shooting several, I found, upon dissecting, that they were barren birds, which accounted sufficiently for their presence here at this time. During the migrations it is abundant.

No.	Sex.	Locality.	Date.	Collector.
221	♀	Santa Barbara, Cal	July 7	H. W. Henshaw.
222	♀	......do	July 7	Do.

156. *Calidris arenaria*.—Sanderling.

This bird occurs more or less numerously on the coast during the migrations. I took a single specimen on the Santa Cruz Island in June. Its journey northward had been interrupted by an injury, possibly a gunshot wound.

No.	Sex.	Locality.	Date.	Collector.
740	Ad.	Santa Cruz Island, Cal	June —	H. W. Henshaw.

157. *Limosa fedoa*, (Linn.).—Great Marbled Godwit.

The Godwit appears in large flocks on the Californian coast in spring and fall. June 16, a fine specimen was brought me by Mr. J. A. Hasson, who shot it on some salt-ponds near Los Angeles, where he stated he saw many others. The bird was in worn breeding-dress, and I am inclined to judge that many find here their summer-home. According to Dr. Cooper, it abounds at Shoalwater Bay, Washington Territory, though he thinks all pass north to breed. The Willet (*Totanus semipalmatus*) also occurs abundantly on the coast.

No.	Sex.	Locality.	Date.	Collector.
23	Ad.	Los Angeles, Cal	June 16	H. W. Henshaw.

158. *Totanus melanoleucus*, (Gmel.).—Greater Yellowlegs.

Occurs numerously during the migrations both on the coast and in the interior. I am not aware that the Lesser Yellowlegs has actually been recorded from the Pacific coast. Its occurrence here is, however, extremely probable, as the range of the two species is almost exactly coincident.

159. *Tringoides macularius*, (Linn.).—Spotted Sandpiper.

An individual of this species seen now and then on the fresh-water streams of the interior.

160. *Heteoscelus incanus*, (Gm.).—Wandering Tattler.

The Wandering Tattler, as this bird is aptly named, possesses a very extreme distribution, being found on the islands of the Pacific generally, and from Russian America to Australia. It has been found in Washington Territory by Dr. Cooper, where, however, it was not common. Santa Cruz Island was the only place where I enjoyed the opportunity of seeing the bird, though it is found, as I learned from others, on the other islands also. Captain Forney, of the Coast Survey, who has paid considerable attention to the birds of these islands, presented me with a specimen, one of quite a number he secured on San Miguel, where I should judge the bird must occur in considerable numbers. They appear not to be a bird of the sandy shores at all, but resort exclusively to the rocks covered with sea-weed, where they follow the tide as it ebbs and flows, running back and forth and picking up the minute worms and marine animals, of which they find a great abundance. In motions, they simulate exactly the little Spotted Sandpiper, and have the same curious "tip-up" motion of the body, which they indulge in at moments of rest from feeding or when attentively looking about them. They fly, too, with the same deliberate wing-beats, the pinions being slightly decurved, the tips pointed downward. Their voices are, however, wholly different, and the notes are very loud and harsh when compared with the smooth whistle of the other species. I found them usnally solitary and quite watchful and full of distrust, though I found myself once or twice within a few feet of one of them, and was allowed a most excellent chance to watch their motions. This was June, and the species was unquestionably paired and breeding, though I obtained no hint of their method of nidification.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
6	♀ ad.	Santa Cruz Island, Cal	June 4	H. W. Henshaw	6.70	3.13	1.54	1.37

161. *Numenius longirostris*, Wils.—Long-billed Curlew.

This Curlew is numerous during the migrations. It was present in large flocks on the borders of Kern Lake in August. The Esquimaux Curlew (*N. borealis*) is also said by Heermann to be common in the San Francisco market.

TANTALIDÆ.—IBISES.

162. *Ibis thalassinus*, Ridgw.—Glossy Ibis.

This Ibis is probably a summer resident in suitable localities throughout the interior of the State. It was a common bird at Kern Lake in August; flocks of considerable size being seen there.

ARDEIDÆ.—HERONS.

163. *Ardea herodias*, Linn.—Great Blue Heron.

Of common occurrence.

164. *Herodias egretta*, (Gmel.).—Great White Egret.

This Heron was seen on quite a number of different occasions in various parts of Southern California. It appears to be a rather common summer resident. The little Egret (*Garzetta candidissima*) is also said by Heermann to be numerous.

165. *Butorides virescens*, (Linn.).—Green Heron.

Common.

166. *Botaurus minor*, (Gmel.).—Bittern.

Quite numerous on the marshes throughout the State.

GRUIDÆ.—CRANES.

167. *Grus canadensis*, (Linn.).—Sand-hill Crane.

Of common occurrence in California.

RALLIDÆ.—RAILS.

168. *Rallus elegans*, Aud.—King Rail.

This Rail was common in certain marshy spots close to the sea at Santa Barbara. They retired during the day into the beds of tall rushes, which served to screen them from all enemies, as well as from the glaring sun. By July 1 the young were out and able to accompany their parents after food. They began to be active about sunset, heralding the approach of dusk by loud outcries. They were not altogether quiet during the day, and they are probably forced to forage more or less during the uncongenial hours of day to satisfy the hunger of their young.

169. *Rallus virginianus*, Linn.—Virginia Rail.

This is perhaps the most generally distributed of the family throughout the United States. It appears to be quite numerous in Southern California; as much so in certain localities as anywhere in the East. I found it abundant at Walker's Basin in November, and it probably winters throughout the southern half of the State. The Sora Rail (*Porzana carolina*) was not noticed by us, nor do I find it recorded from the west coast. The Black Rail (*P. jamaiciensis*) appears to be fully as numerous in California as in any other part of its habitat. From information from Mr. Gruber I should judge it was rather common in the extensive tulle swamps in the State. It has also been found by this gentleman on the Farallone Islands. Its small size and skulking habits, combined with the inaccessibility of its swampy haunts, render the procuring of specimens exceedingly difficult.

170. *Fulica americana*.—Coot; Mud-hen.

Very abundant on the fresh-water ponds throughout the State where they breed. The species is a resident one, though a migration in spring and fall occurs with perfect regularity.

ANATIDÆ.—GEESE AND DUCKS.

171. *Anser hyperboreus*, Pallas.—Snow-goose.

Great numbers of this Goose were seen on the prairies and in the stubble-fields south of San Francisco in November.

172. *Anser albifrons* var. *gambelii*, Hartlamb.—White-fronted Goose.

Immense numbers of this species winter in California, returning from their northern breeding-grounds in October and November.

173. *Branta canadensis*, (Linn.).—Canada Goose.

Very numerous in fall and winter.

174. *Branta canadensis*, (Linn.), var. *hutchinsii*, Rich.—Hutchins's Goose.

Vast numbers throng the State, both along the coast and on the interior prairies.

175. *Anas boschas*, Linn.—Mallard.

The Mallard is found in great abundance in fall and winter, while many doubtless remain to breed in the lakes. It is found on the mountain-streams to a height of even 9,000 feet. In fall, it is quite terrestrial in its mode of life, and gleans a rich harvest from the grain-fields.

176. *Dafila acuta*, Linn.—Pin-tail.

Numerous during the migration.

177. *Chaulelasmus streperus*, Linn.—Gadwall.

More or less numerous in the fall and winter. I saw numbers in the San Francisco market in November.

178. *Mareca americana*, (Gmel.) —American Widgeon.

Numbers seen in Walker's Basin in November. Abundant in winter.

179. *Querquedula carolinensis*, (Gmel.).—Green-winged Teal.

Abundant on the fresh-water courses throughout the State. Both the Blue-winged and the Red-breasted Teal occur in abundance in California; the latter as a summer resident leaving the State early in fall for farther north.

180. *Spatula clypeata*, (Linn.).—Shoveler.

Very numerous in the fall and winter.

181. *Fuligula marila*, (Linn.).—Greater Blackhead.

Abundant in fall and winter; chiefly along the coast.

182. *Fuligula ferina*, (Linn.), var. *americana*, Eyton.—Redhead.

Common in fall and winter.

183. *Fuligula vallisneria*, (Wils.).—Canvas-back Duck.

This Duck was present, though not numerous, in Walker's Basin in November. Dr. Newberry speaks of the species as being found in large numbers in the bays and rivers of the State in fall and winter.

184. *Bucephala clangula*, (Linn.).—Golden-eye.

An abundant species, visiting the State in fall and remaining through the winter. I was informed by Mr. Gruber that the Barrow's Golden-eye (*B. islandica*) was found occasionally in the San Francisco markets, where he had procured specimens. As on the east coast, it breeds quite far to the north, descending chiefly along the coast in winter.

185. *Bucephala albeola*, (Linn.).—Butter-ball.

Perhaps the most common and widely-distributed of the genus.

186. *Harelda glacialis*, (Leach).—South Southerly; Old Squaw.

Doubtless an abundant visitor to the sea-coast of the State in winter. A single specimen was shot at Santa Barbara in June. This bird, a female, had from some cause or other remained behind, and the plumage was so much worn and in such a faded condition as to be scarcely recognizable.

No.	Sex.	Locality.	Date.	Collector.
9	♀	Santa Barbara, Cal	June 9	H. W. Henshaw.

187. *Œdemia perspicillata*; *Melanetta velvetina*; *Pelionetta perspicillata*.

The three species of Sea Coot occur abundantly all along the Californian coast in winter.

In passing down the coast in June from San Francisco to Santa Barbara, I saw large numbers of Coot all along the shore and in the little bays. These were probably the young and barren birds, which did not go north to breed. Of what species these were,

or whether, as is probable, the three were not represented, I am not able to say. About the island of Santa Cruz, they were to be seen at this time by hundreds. A single one shot here proved to be the *Melanetta;* but I am reasonably sure that all three birds were present. Their fishy diet and coarse flesh render them, if edible at all, anything but palatable food, and hence they are scarcely ever disturbed. As a result, they have become very tame, and approach close to the wharves and vessels in the harbor of San Francisco with the utmost unconcern.

188. *Mergus serrator*, (Linn.).—Red-breasted Merganser.

Very numerous in fall and winter, both on the coast and inland. A single bird, worn and faded, was shot, June 7, at Santa Barbara. The *Mergus merganser* also occurs in large numbers.

189. *Mergus cucullatus*, (Linn.).—Hooded Merganser.

Appears in fall in large numbers as a migrant.

PELECANIDÆ.—PELICANS.

190. *Pelecanus trachyrynchus*, (Lath.).—White Pelican.

The most conspicuous of all the feathered tribe that we found assembled at Kern Lake were the White Pelicans, noticeable both from their great size and the extreme whiteness of their plumage. This was in August, and the birds had probably remained here all summer, breeding somewhere about the lake. During the hours of mid-day they appeared to give up fishing entirely, and, betaking themselves to some dry spot along the lake, they dozed away the unoccupied hours, standing motionless in long rows, with their heads drawn on their breasts, and appearing lost to all around them. They were not, however, so taken up with their own meditations as to be forgetful of safety, and roused themselves always in time to be up and away ere I could get fairly within gunshot. They breed very early. Captain Bendire found the eggs of this bird in Oregon as early as April 12, though they continued laying eggs till into May. They are present upon all the inland waters of any size in California, and less often and in fewer number are found upon the coast.

191. *Pelecanus fuscus*, (Linn.).—Brown Pelican.

Pelecanus fuscus, Newb., P. R. R. Rep., vi, 1857, 108.— Bd., B. N. A., 1858, 870.—Heermann, P. R. R. Rep., x, 1859, 72.—Coop & Suckl., ibid., 12, 1860, 266.—Coues, Key N. A. B., 1872, 300.

In contrast to the habits of its more showy white cousin, which resorts to the fresh waters of the interior, breeding and living there, the Brown Pelican is found exclusively on the sea-coast, resorting to the bays and shallow inlets where are found the small fry which constitute its food. The waters about San Francisco are particularly favored by this bird, and in a trip across the bay one may see hundreds of these huge, uncouth birds winnowing their way from one fishing-ground to another with slow, measured wing-beats, or diving with sure aim from mid-air on some luckless fish swimming near the surface. Undisturbed, they roam the bay at will, viewing the approach of steamer and vessel with utmost unconcern, and often, indeed, remaining on the water till almost run down by the approaching craft, when they lazily clear the water with heavy strokes and fly from almost under the bows. On account of their heavy bodies and the length of wings, they raise themselves with some little difficulty, and it requires a number of quick, vigorous strokes, delivered upon the surface of the water, ere they can get fairly on the wing. They progress easily and firmly, now flopping their broad wings till the desired momentum is obtained, now gliding without motion on outstretched pinions. When fishing, they keep a few feet, from 10 to 20, above the water, and when a fish is discovered they gather themselves for the effort by a few short strokes of the wing; then with head down descend, making the water foam with the violence of their plunge. At night-fall they retire from the bay to distant sleeping-grounds, probably, as noticed by Dr. Newberry, to the broad expanse of the ocean, and when going and coming they fly in lines, and just clear the surface of the water, falling and rising with the heaving waves.

About the island of Santa Cruz, these birds were uncommon, and I saw but few.

GRACULIDÆ.—CORMORANTS.

192. *Graculus dilophus*.—Gray Double-crested Cormorant.

This species nests on the Farallone Islands in great abundance, as also upon the Santa Barbara group. It is common along the coast, and is also found on the large bodies of water inland, as at Kern Lake, where it was numerous.

193. *Graculus penicillatus*, (Gray).—Brandt's Cormorant.

This is one of the Cormorants found upon the Farallone Islands in summer, and no doubt breeds also on the Santa Barbara Islands, though I was not able to satisfy myself perfectly of its presence on Santa Cruz in June. A specimen, however, taken on San Miguel was very kindly presented me by Captain Forney, who shot numbers of the same kind.

194. *Graculus violaceus*, (Gray), var. *bairdii*, Cooper.

The Violet-green Cormorant of Oregon, Washington Territory, and to the northward, is represented on the Californian coast by a smaller bird, which appears to be its southern race. The difference is one chiefly of size, the discrepancy being in this particular considerable and out of the range of purely individual differentiation. The proportions, colors, &c., of the two appear to be identical.

This bird is very numerous all along the coast of Southern California, and probably reaches northward into Oregon. I saw many in San Francisco Bay in May, and on reaching the islands of the Santa Barbara Channel it was found congregated in great numbers. Most of the places they had selected as nesting-sites were inaccessible to me. At low tide I succeeded in entering one of the gloomy caverns, where a dozen pairs had established themselves. The nests were merely collections of weeds and sticks matted together and placed upon the shelves of rock sufficiently high to be out of danger from the tide. This was June 4, and they all contained young in the downy state. The old birds forsook the place in a mass, and flew wildly about the entrance, but without attempting to re-enter, though the young birds kept up a vociferous calling all the while. In flying about the island, the old birds passed within easy gunshot of the rocky points, and I could have procured all the specimens I desired had it not been for the strong surf which swept the shores and made their recovery very hazardous. They never ventured over the land. It is a constant habit with these birds, having spent the morning in fishing, and having appeased their hunger, to sit in groups on the cliffs which immediately overhang the water, and often in such numbers as to blacken the rocks. When disturbed, those nearest to the edge drop overboard, while those in the rear scramble forward in the most awkward way, and, having made the plunge, swim underneath the water till they have gained a safe distance.

The present species was immediately recognizable among its congeners by its small size. The white flank-tufts are, I think, a distinguishable feature of the breeding-period, and are soon lost. They were seen only in the males, and the size is extremely variable; being in some individuals scarcely discernible, while in others they were conspicuous at a long distance.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
784	♂ ad.	Santa Cruz Island, Cal	June —	H. W. Henshaw...	9.75	7.00	1.85	1.90
785	♂ ad.	......do	June —	....do	9.75	7.00	1.78	1.85
783	♀ ad.	......do	June —	....do	10.10	7.50	1.97	2.10

LARIDÆ.—GULLS; TERNS.

195. *Larus argentatus*, (Brünn.,) var. *occidentalis*, Aud.—Pacific Herring Gull.

This Gull is very numerous in San Francisco Harbor, as it is indeed in all the bays and inlets of the coast, and its numbers are perhaps greater the year round than any other species. Free from molestation, they have become almost semi-domesticated, and fly about the wharves and over the vessels with an impunity only born of long immunity from danger. The rocky islets along the coast furnish them with safe and plentiful breeding-grounds. At Santa Cruz, thousands had congregated and were nesting in early June. In a few instances, they had attempted to nidificate on the mainland, but a few feathers and bits of egg-shells about the nests told in each case the fate of parent and eggs; their enemy was the foxes, whose numbers are scarcely without limit. Only one of the small adjoining islets was accessible to me. A few pairs had nested here. The nests were made of a good generous supply of sea-weed and like material, well matted together, the cavity being quite deep. The eggs are of a greenish olive, spattered profusely and irregularly with blackish markings.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
11	Ad.	Santa Cruz Island, Cal..	June 9	H. W. Henshaw...	16.75	7.00	2.29	2.27
22	♀ ad.	......do	June 11	....do	15.50	6.60	2.08	2.34
781	Ad.	......do	June 11	....do	16.10	6.00	2.34	2.48

196. *Larus* (*Blasipus*) *heermannii*, (Cass.)—Heermann's Gull.

A very large flock of these Gulls was seen pursuing their way along the shore near Santa Barbara, and two or three hours later I came upon them where they had settled upon a rocky point which jutted out into the water. Many were engaged fishing, hovering over the half-submerged kelp-covered rocks, the shallow water surrounding which evidently harbored the smaller kinds of fish. In three or four discharges of my gun I obtained a dozen specimens, when the whole mass flew wildly about as though fascinated by the sight of their dead comrades, and it was some time ere they left the place, which they did in a long straggling flock. The whole flock was composed of old males, and from their long and direct flight it seemed pretty evident that the journey was one between their breeding-grounds and this fishing-place, where was had an abundance of some food, perhaps peculiarly fitted for the young. The species is a common one all along the coast, and breeds upon many of the sea-islands.

Several other species of Gulls and at least one species of Jaeger were observed along the coast; but my acquaintance with them was altogether of too unsatisfactory a nature to warrant any mention of them here.

No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Bill.	Tarsus.
39	♂ ad.	Santa Barbara, Cal......	June 24	H. W. Henshaw...	13.25	6.00	1.70	1.98
40	♂ ad.	......do	June 24	....do	13.90	6.20	1.83	1.98
41	♂ ad.	......do	June 24	....do	13.70	6.00	1.77	2.03
42	♂ ad.	......do	June 24	....do	13.25	5.75	1.75	1.90
44	♂ ad.	......do	June 24	....do	14.25	6.00	1.85	2.09

197. *Sterna regia*, (Gamb.)—Royal Tern.

This Tern probably reaches no farther to the north than the coast of California, where it appears to be of rather common occurrence. I saw it up as far as San Francisco. A specimen obtained on San Miguel was presented by Captain Forney, to whom I am under obligation for other similar kindnesses. Upon this and perhaps others of the Santa Barbara group, the species breeds. At least one other of the small Terns was seen about San Francisco, but its identity could not be established.

198. *Hydrochelidon lariformis*, (Linn.).—Black Tern.

Saw this species but once, in the interior, north of Los Angeles; according to other observers, the bird is numerous on the inland waters.

PROCELLARIIDÆ.—PETRELS.

199. *Cymochorea homochroa*, (Coves.)—Lesser Black Petrel.

Petrels are quite numerous along the coast of California. A specimen of the above species, so identified by Dr. Coves, was given me by Captain Forney, who found these birds breeding in great numbers on San Miguel. As usual, they were nesting in burrows. The relationship of this bird with the *C. melania* is somewhat obscure, and a good series to confirm this supposed distinctness is greatly to be desired.

No.	Sex.	Season.	Locality.	Collector.	Wing.	Tail.	Bill.	Tarsus.
....	Ad.	Summer.	San Miguel Island, Cal.........	Captain Forney.	5.35	8.35	0.60	0.88

COLYMBIDÆ.—LOONS.

200. *Colymbus torquatus*, (Brünn.)—Great Northern Diver.

Numerous on the California coast in fall. The *C. arcticus* var. *pacificus* is also known to be common in winter.

PODICIPIDÆ.—GREBES.

201. *Podiceps auritus*, (Linn.), var. *californicus*, Heerm.—Eared Grebe.

Coincident with its general dispersion in the West, this Grebe appears to be distributed over California. We only saw it in the fresh-water ponds, though it also occurs along the shore.

No.	Sex.	Locality.	Date.	Collector.
298	♂ ad.	Near Fort Tejon, Cal	July 24	H. W. Henshaw.

202. *Podilymbus podiceps*, (Linn.).—Carolina Grebe.

Present in numbers on many of the fresh-water ponds of the interior; found also on the coast. The *P. cornutus* was not recognized by us, though it, too, is found numerously in fall.

ALCIDÆ.—AUKS.

203. *Fratercula cirrhata*, (Pallas).—Tufted Puffin.

This Puffin, though more commonly known as a resident of the far north, was ascertained by us to inhabit the islands of the Santa Barbara group in summer. It was not uncommon, and was nesting apparently in the crevices of the cliffs, from which I frequently saw it flying back and forth. Heermann likewise found it breeding in numbers on the Farallone Islands.

204. *Uria columbia*, (Pallas).—Western Guillemot.

The Santa Barbara Islands form, too, it is probable, about the southern limit for this species in summer; among them it is, however, numerous—breeding in the caves and hollows of the generally inaccessible cliffs. Early one morning, while out collecting, I noticed many of these birds frightened at the report of my gun, streaming out of a little ravine hemmed in by high rocky cliffs, and terminating at the upper end in a low narrow cave. The tide being at its lowest, I succeeded in gaining the entrance, and, crawling on my hands and knees for a short distance, I soon had the satisfaction of placing my hands on the eggs. Their housekeeping arrangements are of the simplest kind. No nest at all is prepared to receive the eggs; but these were deposited on the sandy floor of the cavern, and at its farther end, where it was so dark that I had to strike a match to see them at all. Other pairs had availed themselves of the nooks and fissures in the face of the wall, and laid their two eggs on the bare rock. I succeeded in finding a few only of the many eggs that must have been deposited here, as the shelves of the rocks were, in many instances, too high to be reached. The birds submitted to the pillage without a murmur, though not without solicitude, as their anxious manner as they swam back and forth at the entrance to the ravine, keeping, however, well out of gunshot, sufficiently evinced.

The eggs are a faint greenish white, spotted mostly at the larger end with irregular blotchings.

Very respectfully, your obedient servant,

H. W. HENSHAW.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in Charge.

APPENDIX H 9.

REPORT ON THE ORTHOPTERA COLLECTED BY THE UNITED STATES GEOGRAPHICAL SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN, UNDER THE DIRECTION OF LIEUTENANT GEORGE M. WHEELER, DURING THE SEASON OF 1875, BY SAMUEL H. SCUDDER.

CAMBRIDGE, MASS., *May* 29, 1876.

SIR: The explorations during the past season covered a region from which we have hitherto received very little material; on the eastern slope of the Rocky Mountains scarcely any *Orthoptera* have been collected south of Colorado, while the Orthopterous fauna of the entire Pacific coast has been but little studied. It is, then, hardly surprising that of the fifty species here enumerated, mostly forwarded to me in half a dozen small bottles, nearly one-half should prove new to science. It would have been more satisfactory if the descriptions given here could have been generally based on a richer material, and upon specimens which had never been subjected to an alcoholic bath; for not only are most of the colors obliterated by long immersion in alcohol, but the structural features are falsified by the unnatural prominence given to all angulations, and the deeper hollowing to sulcations, or even to flat surfaces. The nature of the explorations, however, renders it nearly impossible, at times quite impossible, to preserve and transport objects of natural history in any other way; and the rich proportion of novel forms which the moderate collections of a single year have exposed will in part make amends for the somewhat unsatisfactory nature of the material.

It should be added in this connection that all the specific descriptions which follow (and also all of the generic descriptions, which cover only the species mentioned in this report, excepting *Hadrotettix*) have been based upon specimens more or less imperfect from their preservation in alcohol, with the exception of *Steiroxys melanopleura*, *Arphia*

teporata, *Camnula atrox*, and *Œdipoda venusta;* of all of these I had in my own collection ordinary cabinet-specimens.

It had been my intention to present at this time some general observations upon the geographical distribution of North American *Orthoptera*, and also a revision of the North American *Pezotettigi* and *Œdipodidæ*, so richly represented in this collection. Other engagements prevent the present fulfillment of this intention, and I can only offer the student, in place of the latter, brief tables of the species obtained by the Survey during this single season, which will be found preceding the groups mentioned.

A few specimens in an immature condition have not been determined.

Respectfully submitted.

SAMUEL H. SCUDDER.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in Charge.

GRYLLIDES.

1. *Gryllus abbreviatus* Serv.—Two males are referred to this species with some doubt; one is from the Colorado River, California, collected July 28 by W. Sommers, No. 867; the other from Santa Cruz Island, collected in June by Dr. O. Loew, No. 840.

2. *Gryllus neglectus* Scudd.—A number of specimens were taken on the plains of Northern New Mexico, eastern slope, October 14–31, and others in Southern Colorado June 11–20, by Lieut. W. L. Carpenter.

3. *Gryllodes lineatus*, nov. sp.—Head above blackish brown, conspicuously striped longitudinally with pale testaceous; a broad band follows the upper limits of the antennal sockets and the eye, and above the middle of the latter emits an oblique, slender shoot to the pronotum; midway between this and a testaceous median line is a slender, rather short, testaceous stripe, reaching neither extremity of the vertex; upper limit of clypeus brownish, rest of face and mouth-parts pale testaceous, the lower part of clypeus white; antennæ brownish testaceous; apical joint of maxillary palpi tipped with brown, obliquely docked on the apical third. Pronotum quadrate, the sides slightly rounded, black, with small, lateral, pale, testaceous spots, and a distinct median sulcation. Tegmina half as long as the abdomen, testaceous, the lateral field with four nervures, of which the lowest is forked from the base, the upper half of the field blackish brown; wings of the same length as the tegmina. Legs yellowish, the hind femora heavily marked with dark brown in crowded, oblique, abbreviated lines; hind tibiæ dusky beneath, the extreme tip of spines black; first hind tarsal joint half as long as the hind tibiæ, armed above on either side with a row of half a dozen rather stout recumbent spines. Abdomen black, the last superior segment and the cerci light brown. Length of body, 11.5^{mm}; of tegmina, 3.5^{mm}; of hind tibiæ, 4.6^{mm}; of cerci, 5.5^{mm}. One ♂ taken between Virgin River and Fort Mojave, Arizona, August, W. Sommers, No. 858.

This species is closely allied to *G. pusillus* (Burm.), but has short wings.

LOCUSTARIÆ.

4. *Stenopelmatus talpa* Burm.—Specimens in various stages of development were taken on Santa Cruz Island, in June, by Dr. O. Loew, No. 851; at Los Angeles, Cal., in June, by J. Brown, No. 808; at Los Angeles and Santa Barbara, in June, by C. J. Shoemaker, No. 798; at Santa Barbara, June 10, by Dr. O. Loew; and, in July, by H. W. Henshaw, No. 880; same place, July 1, H. W. Henshaw, No. 1005; and, in the Mojave Desert, in July, by Dr. O. Loew, No. 935.

5. *Udeopsylla robusta* (Hald.) Scudd.—One ♂, Northern New Mexico, August to September, Lieut. W. L. Carpenter.

6. *Ceuthophilus pallidus* Thom.—Two ♂, five ♀, Southern Colorado, June 11–20, Lieut. W. L. Carpenter; plains of Northern New Mexico, eastern slope, October 14–31, Lieut. W. L. Carpenter.

7. *Ceuthophilus denticulatus*, nov. sp.—Yellowish brown, the segments narrowly margined posteriorly with brown, the face and under surface of the body paler; frontal tubercle a scarcely perceptible swelling; eyes subpyriform, small, not very prominent. Fore coxæ unarmed; all the femora, as well as the front and middle tibiæ, minutely serrulate beneath; fore femora with but a single apical interior spine; fore tibiæ with three pairs of spines besides the apical ones; middle femora with three or four minute spines on the outer carina; middle tibiæ with three pairs of inferior spines besides the apical ones, and two distant spines on the posterior face, nearly equidistant from each other and either extremity; posterior femora without spines; posterior tibiæ rather coarsely serrulate throughout on either carina, and provided also with four pairs of long superior spines, besides those at the apex. Ovipositor a little longer than the

middle femora, the exterior valves turned abruptly upward and very finely pointed at the tip, the inner valves furnished with five curved aciculate teeth, growing larger apically, and there equaling the breadth of the ovipositor. Length of body, 15mm; hind tibiæ, 9.25mm; of ovipositor, 4.75mm.

1 ♀, Santa Barbara, Cal., June 10, Dr. O. Loew.

This species is closely allied to *C. californianus* Scudd., but differs decidedly from it in the length of the ovipositor, which is nevertheless shorter than in most of the other species, and from all species known to me in the extreme length of the teeth of the ovipositor. Thomas's *C. castaneus* is probably to be referred, as he suggests, to my *C. californianus*, as the measurement given of the hind femora of the latter should read .32 in instead of .22 in, a typographical error to which my attention was first called by his description. I may add that while the hind femora of *C. californianus* are not spined beneath, they are minutely serrulate throughout, as in the present species.

8. *Anabrus coloradus* Thom.—This species differs from *A. simplex* Hald., in its smaller size, shorter pronotum, in the character of the posterior lobe of the same, which is slightly broader, distinctly though but slightly carinate, with lateral carinæ, distinct though obtuse and slightly more docked posterior border; the lower border of the deflected lobes from front to back is broadly margined with pale yellow, made more conspicuous posteriorly by being broadly edged above with reddish brown. As in that species, the tegmina and wings are completely covered by the pronotum in both sexes. The ovipositor is gently and regularly curved, while in *A. simplex* it is straight, and is black, excepting next the base of the lower valves and next the extreme base of the upper valves, while in *A. simplex* it is black only next the apex; the male cerci are very sparsely and briefly pilose, rather stout, subcylindrical, dividing at about the middle into two fingers, an inner, short, cylindrical, thumb-like process, directed a little upward, less than twice as long as broad, and a gently incurved, tapering, pointed finger; the male cerci of *A. simplex*, on the other hand, are laterally compressed, and have both the appendages abbreviated. Length of body, ♂, 22mm; ♀, 20mm; of antennæ, ♂, 20mm (?); ♀, 25mm; of pronotum, ♂, 8mm; ♀, 8.75mm; of hind tibiæ, ♂, 12.25mm; ♀ 13.25mm; of ovipositor, 18.5mm.

2 ♂, 4 ♀, Southern Colorado, June 11–20, Lieut. W. L. Carpenter; Taos Peak, Sangre de Cristo Mountains, New Mexico, at a height of 13,000 feet, (above timber,) Lieut. W. L. Carpenter.

This species is closely allied to *A. simplex* Hald. The species described and figured under this name by Herman (Verh. zool.-bot. Gesellschaft, Wien, xxiv, 209, tab. vi, figs. 76–86), though undoubtedly a true *Anabrus*, can certainly not be the *A. simplex* of Haldeman, but is an allied species, unknown to me in nature, in which the ovipositor and male cerci are different, and in which the tegmina (at least of the male) project beyond the pronotum. Apparently it is Herman's species which is figured under the name *A. simplex* by Glover (Ill. Ent. N. Amer. Orth., pl. ix, fig. 1).

It may also be remarked in this place that Thomas (Proc. Acad. Nat. Sci. Phil., 1870, 74 et seq.) has strangely separated *A. purpurascens* Uhl., from this genus, because the prosternum is not spined, whereas the genus was founded upon *A. simplex*, which has an amucronate prosternum! and although he subsequently explains it (Geol. Surv. Montana, 438 et seq.) from his never having seen *A. simplex* when his first paper was written, he still further confuses his readers by stating that *A. Haldemanii* Gir., has the prosternum distinctly spined, whereas it is as clearly amucronate as is the prosternum of *A. simplex*.

9. *Steiroxys melanopleura*, nov. sp.—The top of the head is tumid, well rounded; pronotal shield short but narrow, compressed, the deflected lobes falling off so that the lower part of the prothorax is three times as broad as the upper; three equal but slight longitudinal carinæ extend its entire length, the median broken near the middle by a ψ-shaped impression and crossed anteriorly at the end of the anterior sixth by a slight transverse sulcus, which cuts the lateral carinæ and passes on to the deflected lobes; from this sulcus forward the lateral carinæ diverge slightly; the deflected lobes are divided by a straight transverse impression into two unequal halves, and the deepest point of the lobes is just behind this impression; behind this the hinder edge of the lobe passes upward in a nearly straight, oblique direction, and the posterior margin of the lobe is very broadly rounded. Tegmina very short, broadly rounded, somewhat shorter than the pronotum, with very prominent veins. Fore tibiæ with four spines on the anterior face; outer face of middle tibiæ with five or six alternate spines in a double row; hind legs very long, the terminal interior tibial spine much longer than the first tarsal joint. Male cerci short, stout, cylindrical, suddenly recurved, and tapering, forming a short, horny, black hook; subgenital plate excised, with a slightly obtuse angle apically, the styles as long as the width of the extreme apex of the plate. Length of body, 26mm; of pronotum, 7.75mm; of tegmina, 5.5mm; of hind tibiæ, 27mm.

1 ♂, Los Angeles or Santa Barbara, July, C. J. Shoemaker, No. 224.

I place this species in Herman's genus *Steiroxys*, although it differs from it in some structural features. Another species of the same group from California is in my collection.

PLAGIOSTIRA (*πλάγιος, στεῖρα*), *nov. gen.*

Head of moderate size, well rounded, more of the hinder part than usual concealed beneath the pronotum, which is slightly expanded to receive it; the projecting part of the vertex rather slight, narrow, tapering, deeply cleft transversely between the antennæ; eyes round, small, rather prominent. Pronotum short, equal, shallow, flat, and depressed above, the sides nearly vertical; dorsal and deflected lobes separated by very prominent, but obtusely-rounded, transversely wrinkled carinæ, subobsolete anteriorly; anterior margin straight, posterior margin broadly rounded, next the middle slightly excised; dorsal surface flat, depressed, with a very slight longitudinal impressed line, a transverse, slightly arcuate, broad furrow just behind the middle, and a similar but narrow furrow near the anterior margin, the latter extending nearly across the deflected lobe; between these two furrows the dorsum is slightly tumid; the deflected lobes are exceedingly shallow, deepest at about the middle, but scarcely one-third as deep as long, very obtusely angled, and a little rounded at this point, the lower margin a little oblique, and meeting the front margin sharply at a little more than a right angle, the posterior margin scarcely convex, nowhere excavated; prosternum unarmed. Tegmina squamiform, densely reticulated, not gibbous. Fore tibiæ with a single outer row of four spines on the anterior face; middle and hind tibiæ with a similar double row of nearly opposite spines on the outer surface of the former and on the inner surface of the latter; hind legs very slender, and not remarkably long. Mesosternum and metasternum, as well as all the coxæ, bluntly mucronate laterally. Abdomen bluntly ridged above, but not carinate. Supraanal plate acutely triangular with apically submucronate lateral swellings occupying most of the base. Ovipositor as long as the body, straight or nearly so, not serrate at tip; subgenital plate rather deeply and very angularly excised at apex, otherwise simple. The male unknown.

The shallow, flat, quadrate pronotum, carinate laterally only, the anterior portion protecting the head, together with the slender femora and sharply angulate supraanal plate, are striking features of the genus.

10. *Plagiostira albonotata*, nov. sp.—Very pale brownish yellow, the face paler, the whole marked conspicuously with chalky white; a transverse, faint, white stripe follows the lower edge of the cheeks; another, broader and more distinct, starts at the lower edge of the eye and passes backward along the lower margin of the pronotum nearly to the hinder edge; another runs back from the top of the eye to the first transverse sulcus of the pronotum; the middle of the deflected lobes of the pronotum is more or less clouded with it; dashes occur on prominent points on the pleura and outer face of the coxæ; the top of the head bears a pair of diverging longitudinal streaks, equidistant from each other and the eyes; the middle dorsal lobe of the pronotum has two small round spots at the middle of the sides, and two other smaller ones in front of and within them; the posterior lobe has a broad longitudinal dash in the middle of either lateral half; and the abdomen has a pair of dorso-pleural, subcontinuous streaks, and a pair of pleural, discontinuous, oblique streaks, the former with a minute round spot of the ground-color at the distal end of the streak of each segment; tegmina dark brown, the fine reticulations paler; wings shining black, nearly as large as the tegmina. The vertical process of the head is very slightly sulcate longitudinally; the ovipositor is scarcely curved downward, equal nearly to the tip, tapering to a very fine point. Length of body, 21.75^{mm}; of pronotum, 7.9^{mm}; of tegmina, 5^{mm}; of hind tibiæ (which are longer than the femora), 18.2^{mm}; of ovipositor, 23.5^{mm}.

1 ♀, Northern New Mexico, August, September, Lieut. W. L. Carpenter.

11. Another species of this group (*Decticidæ*) was brought from the same locality as the last, but in too immature a condition to determine.

12. A species of *Phyllophoridæ*, of a genus not yet recognized in the United States, was obtained at Los Angeles, Cal., by Wm. Sommers, No. 822; but it is in so poor a condition that it is better to await further material before description.

ACRYDII.

13. *Acridium vagum* Scudd.—2 ♀, Santa Barbara, June 10, Dr. O. Loew, No. 977; Mojave Desert, J. Thompson, No. 826.

14. *Caloptenus spretus* Uhl.—1 ♂, 1 ♀, Taos Peak, Sangre de Cristo Mountains, Northern New Mexico, at a height of 13,000 feet (above timber-line), in July, Lieut. W. L. Carpenter.

15. *Caloptenus minor* Scudd.—1 ♂, Southern Colorado, June 11–20, Lieut. W. L. Carpenter.

The species of *Pezotettix* in this collection fall into five very distinct groups. The first comprises those of Caloptenoid form and structure, like most of those that have been hitherto described. The second comprises but a single species, *P. marginatus*, remarkable for the simple pronotum, inclined face, and prosternal spine. A third comprises also but a single species, *P. vivax*, in which the head is much broader and higher than the rest of the body, the antennæ are long and rather stout, the first joint of the

same unusually small, the prosternal thorn inclined backward, and the male abdomen scarcely upturned. The fourth consists of a pair of species, *P. jucundus* and *P. enigma*, of a remarkable appearance; they are clumsy-bodied, the front of the prothorax a little tumid, the deflected lobes having their front border nearly as oblique as their hind border, and the hind legs stout; while the antennæ and the prosternal thorn are slight, and the joints of the female abdomen, especially near the tip, are very short and round, and the appendages short, so that the abdomen is almost bluntly rounded at the tip. The fifth group consists again of a single species, *P. pictus*, remarkable for its variegation and its cylindrical body, in which the prosternal spine is bent backward, the tegmina are more than usually lateral, the vertex of the head not at all prominent, and the hind legs very short. I am not aware that any of these groups, excepting the first, is represented in the Old World or upon both sides of the Rocky Mountains in America.

These species may be distinguished by the following table:

1 (8) Metasternal lobes of ♂ distinctly though not widely separated.
  2 (3) Tegmina of opposite sides widely separate throughout; sulcus of anterior border of pronotum as distinct above as on the sides............*pictus*.
  3 (2) Tegmina of opposite sides attingent, in the middle at least; sulcus of anterior border of pronotum distinct only on sides.
    4 (5) Median carina of pronotum equal throughout; hind femora longitudinally striped..*tellustris*.
    5 (4) Median carina of pronotum less distinct on the middle of the anterior than on the posterior lobe; hind femora angularly striped.
      6 (7) Disk of pronotum more or less depressed on either side of the median carina at the posterior sulcus..................................*stupefactus*.
      7 (6) Disk of pronotum not distinctly depressed on either side of the median carina..*Marshallii*.
8 (1) Metasternal lobes of ♂ attingent.
  9 (12) Anterior lobe of pronotum a little gibbous above.
    10 (11) Pronotum scarcely angled posteriorly; tegmina scarcely longer than, or not so long as, the pronotum..............................*jucundus*.
    11 (10) Pronotum distinctly though obtusely angled behind; tegmina distinctly longer than the pronotum..................................*enigma*.
  12 (9) Anterior lobe of pronotum of the usual form.
    13 (14) Median carina of pronotum distinct throughout...........*marginatus*.
    14 (13) Median carina of pronotum distinct only on posterior lobe.
      15 (16) Tegmina and wings more than half as long as the abdomen..*plagosus*
      16 (15) Tegmina and wings not so long as the pronotum ....*vivax*

16. *Pezotettix tellustris*, nov. sp.—Head light brown, mottled heavily above with dark reddish brown, which is absent from a median longitudinal line on the vertex, and a narrow stripe which runs backward from the summit of the eye; eyes pretty large and prominent, the front edge almost straight; vertex between the eyes as broad as the narrowest part of the frontal costa, and twice as broad as the basal joint of antennæ; fastigium scarcely depressed, expanded a little in front of the eyes; frontal costa sparsely punctate, flat, depressed, and broadened a little at the ocellus, below slightly broader than above; antennæ brownish yellow. Pronotum nearly flat above, broadening regularly backward, the posterior margin obtusely and roundly angulated; median carina slight, but equally distinct throughout; lateral carinæ obtuse, but marked by the abrupt descent of the deflected lobes and by the extension over them of the narrow pale stripe behind the eye; upper surface of anterior and front part of posterior lobe dark reddish brown, extending over the head to the eye; remainder of upper surface dark brownish, obscurely and sparsely punctate; deflected lobes of the color of the head, the upper third or more of the anterior lobe dark fuliginous; all the transverse sulcations, which are distinct, marked with black on the sides and the middle half of the dorsum; prosternal spine short, stout, blunt, subconical. Tegmina nearly half as long again as the pronotum, ovate-lanceolate, the tip roundly pointed; they are dark brown, with small quadrate, blackish, scattered spots, and many of the nervures yellowish, or brownish yellow, over short distances; wings about half as long as the tegmina. Hind legs yellow; the femora dark reddish brown, or blackish outside, excepting beneath; above with a basal, an apical, and two intermediate broad patches of the same; apex, excepting lower geniculate lobe, black; spines of tibiæ black; arolium subpyriform, nearly as long as the claws; abdomen yellow; all but the apical margins of the dorsal segments dark reddish brown, deepening into black. Length of body, 18.5^{mm}; of antennæ, 6.5^{mm}; of tegmina, 6^{mm}; of hind tibiæ, 8.5^{mm}.

1 ♀, Northern New Mexico, August and September, Lieut. W. L. Carpenter.

The narrow pale stripes diverging from the summit of the eye backward give this a very different appearance from the two following species.

17. *Pezotettix Marshallii* Thom.—Head light brown, mottled lightly on the face, heavily on the vertex, with brownish fuscous, becoming blackish in a small triangular median spot at the back of the head, and often in a rather broad arcuate band run-

ning from the middle of the vertex between the eyes along their upper edge, but separate from it; eyes moderately large and prominent, the front edge nearly straight in the female; vertex between the eyes broader than the middle of the frontal costa in the ♀, of about equal breadth in the ♂; fastigium broadly and shallowly channeled, most deeply in the ♂, with distinct, and nearly straight lateral carinæ, which melt into the edge of the frontal costa, the latter distantly punctate throughout, slightly narrowed, and scarcely convex at its upper extremity, broadening slightly at the ocellus, which is sunken, and followed beneath by a slight, short sulcation; antennæ uniform brownish yellow. Pronotum above with the posterior lobe nearly flat, the anterior faintly convex, the whole broadening slightly behind, especially in the female, the posterior border convex, with somewhat straight sides, so as to appear almost angulated; median carina very distinct, though slight on the posterior lobe, but faint on the anterior lobe, and scarcely elevated except at the extreme front; lateral carinæ distinct, except anteriorly, but obtuse, the deflected lobes descending vertically; both dorsal and deflected lobes of the color of the head, the posterior lobe a little clearer above and the lower part of the deflected lobes a little paler; upper third or more of the deflected lobes with a dark reddish brown, fuliginous, or blackish stripe extending from the posterior sulcus forward to the eye, narrower on the head, and there margined above with a yellowish line; transverse sulcations distinct, occasionally marked above with black; prosternal spine stout, conical, very blunt at apex. Tegmina less than half as long as the abdomen, subfusiform, the tip roundly pointed; they are dark brown, obscured, clouded, and dotted with black, most of the veins dark castaneous; wings a little shorter than the tegmina. Hind femora dull brownish yellow, the outer and upper faces with two submedian, rather broad, oblique, and angulate blackish fuscous stripes, besides a basal and an apical cloud of the same; hind tibiæ of a warmer yellow, the apical half of the spines black; arolium of same legs yellow, margined with blackish, broad obovate, as long as the breadth of the apex of the hind tibiæ (♂), or obpyriform, as long as the claw and as broad as the apex of the last tarsal joint (♀). Abdomen yellow, heavily mottled above with dark reddish brown, deepening laterally into black at the bases of the segments; last abdominal segment of male terminating in a blunted point; anal cerci of male as long as the width of the hind femoral genicular lobes, slender, straight, tapering on the basal half, the tip bluntly rounded. Length of body, ♂, 17^{mm}; ♀, 25^{mm}; of antennæ, ♂, 6.5^{mm}; ♀, 7.5^{mm}; of tegmina, *a*, ♂, 5.5^{mm}; ♀, 7.75^{mm}; *b*, ♂, 6.5^{mm}; ♀, 9.7^{mm}; of hind tibiæ, ♂, 7^{mm}; ♀, 9^{mm}.

4 ♂, 5 ♀, 4 immature, Taos Peak, Sangre de Cristo Mountains, Northern New Mexico, at a height of 13,000 feet, Lieut. W. L. Carpenter; also, Northern New Mexico, August to September, and Southern Colorado, June 11–20, Lieut. W. L. Carpenter.

I have referred this species to *P. Marshallii* Thom., with some doubt, and therefore have described it anew. Specimens from Taos Peak and Southern Colorado seem to differ only in the length of the tegmina, those marked *a* in the table of measurements coming from Taos Peak and those marked *b* from Southern Colorado. A single specimen from Northern New Mexico (♀) agrees wholly in this respect with one from Taos Peak.

18. *Pezotettix stupefactus*, nov. sp.—Head light brown or yellowish brown, the upper half and sometimes the whole head mottled rather heavily, on the top of the head very heavily, with brownish fuscous, often becoming blackish in a median band on the top of the head, and, less distinctly, above the upper edges of the eyes, as in *P. Marshallii*; eyes, particularly of the male, large, the front border nearly straight in the female; vertex between the eyes broader than the middle of the frontal costa in the female, narrower than it in the male; fastigium distinctly channeled, most deeply in the male, with distinct and nearly straight lateral carinæ, which run into the outer edges of the frontal costa; the latter distinctly punctate near the edges like the whole of the face, nearly equal, but slightly narrower above, the surface flat, with a slight, short, narrow sulcation, in the upper part of which the ocellus is situated; antennæ brownish yellow, becoming dusky toward the tips. Pronotum above nearly flat, the anterior lobe with scarcely perceptible fullness, and on either side of the median carina, at the posterior sulcus, a slight oblique depression; the whole pronotum broadens a little and regularly in passing backward, the posterior margin obtusely and roundly angulated; median carina distinct though slight on the posterior lobe, inconspicuous, excepting in front on the anterior lobe, and in the female nearly obsolete; lateral carinæ distinct, though not prominent; surface of pronotum profusely punctate, almost rugulose behind. Pronotum brownish yellow, darkest on dorsum and profusely flecked with darker colors; upper third or half of deflected lobes with a brownish fuliginous belt extending from the last transverse sulcus to the eye, narrower at the extreme front of the pronotum and on the head; transverse sulcations distinct, only seldom, and then but slightly, marked with black; prosternal spine short, stout, bluntly conical, in the male thickened apically. Tegmina fully half as long as the abdomen, elongate, subfusiform, in the male almost linear, the tip roundly pointed, dark brown, more or less variegated with yellowish and blackish, the small spots showing a tendency to a longitudinal arrangement; most of the veins light; wings a little shorter than the tegmina. Hind femora light yellowish brown, with a pair of conspicuous sub-

median V-shaped dark brown or blackish bands externally, crossing the upper surface transversely; the extreme base and tip are marked with the same color; hind tibiæ yellow, the spines black to the base; arolium as in *P. Marshallii.* Abdomen yellowish beneath, mostly reddish brown above, deepening into black; last abdominal segment of male terminating with a quadrate, slightly and broadly notched margin; anal cerci of male short, very broad, nearly equal, strongly compressed, laminate, the tip broadly rounded, slightly incurved, so that the outer margin is broadly convex, the inner shallowly concave. Length of body, ♂, 17^{mm}; ♀, 20^{mm}; of antennæ, ♂, 7.5_{mm}; ♀, 7^{mm}; of tegmina, ♂, 7.7^{mm}; ♀, 8^{mm}; of hind tibiæ, ♂, (?); ♀, 9.5^{mm}.

1 ♂, 3 ♀, besides many immature, Taos Peak, Sangre de Cristo Mountains, Northern New Mexico, at a height of 13,000 feet, Lieut. W. L. Carpenter.

This species might easily be confounded with the preceding, but is distinct from it in the character of the tegmina, the dorsum of the pronotum, and the anal cerci of the male.

19. *Pezotettix plagosus*, nov. sp.—Brownish yellow marked with dark brown or brownish fuscous; especially noticeable is a medio-dorsal dark stripe, extending from the middle of the vertex between the eyes, where it is not half so broad as the vertex, to or nearly to the end of the pronotum, broadening as it goes, on the posterior half of the pronotum inclosing a median pale line and fading out at the extremity of the posterior lobe; and also a broad belt at the upper limit of the deflected lobes in front of the posterior sulcus extending forward to the eye and fading inferiorly. Vertex between the eyes slightly broader than the frontal costa; fastigium broadly and rather shallowly sulcate, the frontal costa equal, narrowly sulcate below the ocellus. Pronotum broadening slightly posteriorly, the posterior lobe punctate, the median carina distinct only on this lobe, and their slight lateral carinæ moderately abrupt, obtuse, the posterior border obtusely angulated, the angle rounded; prosternal spine very short, straight, stout, pyramidal, pointed. Tegmina not much shorter than the abdomen, obscure brown, mottled with many paler and darker spots (due to the color of the veins), mostly arranged longitudinally in the median field; the costal field is broadly swollen near the base, and beyond it the whole wing tapers nearly to the rounded tip; wings well formed, the veins of the apical half of the preanal field dusky or blackish. Hind femora with two median, angulate, moderately broad, brownish fuscous bands, the arc of the geniculation black; hind tibiæ pale dull glaucous, pale at the base, the spines black-tipped. Anal cerci of male broad at base, rapidly tapering on basal compressed conical half, very slender and nearly equal on the apical half, a little incurved at tip. Length of body, ♂, 18.5^{mm}; ♀, 21^{mm}; o antennæ, ♂, 8^{mm}; ♀, 7.5^{mm}; of pronotum, ♂, 4.75^{mm}; ♀, 5^{mm}; of tegmina, ♂, 11^{mm}; ♀, 11.2^{mm}; of hind tibiæ, ♂, 9^{mm}; ♀, 10.25^{mm}.

1 ♂, 1 ♀, Northern New Mexico, August to September, Lieut. W. L. Carpenter.

20. *Pezotettix marginatus*, nov. sp.—Dull pale olivaceous brown, slightly darker above, with a broad black stripe, occasionally obsolescent, extending from behind the eye, along the upper border of the deflected lobes of pronotum, to the posterior transverse sulcus; pleura sometimes marked with black and the abdomen with a lateral black band, sometimes continuous and equal, sometimes confined to small triangular spots on the segments of the anterior half; hind femora sometimes a little infuscated externally, the genicular lobes sometimes blackish, the hind tibiæ rather dark olivaceous, the apical half of the spines black; the summit of the head is sometimes marked with black in broad median and diverging supraorbital stripes. Face unusually oblique, forming, with the descending fastigium of the vertex, a little more than a right angle; fastigium rather deeply channeled in the male, slightly in the female; frontal costa equal, shallowly sulcate throughout. Pronotum rather long, the dorsum equal, with slightly sloping sides, distinct but rather slight and equal median carina and distinct though very obtuse lateral carinæ; hind border scarcely angulate; prosternal spine rather small, bluntly subconical, inclined a little backward. Tegmina a little longer than the pronotum, simple, but at the extreme tip a little pinched, and tapering to a blunt point; wings a little shorter. Hind legs rather slender, the femora compressed. Last abdominal segment of male terminating in a pyramidal point; anal cerci of same straight, rather stout, moderately long, noticeably but broadly constricted in the middle, the tip larger than the base, gibbous, the whole scarcely depressed, curving slightly downward beyond the middle. Length of body, ♂, 17^{mm}; ♀ (contracted), 14.5^{mm}; of antennæ, ♂, 7.5^{mm}; ♀, 6^{mm}; of pronotum, ♂, 4^{mm}; ♀, 4.6^{mm}; of tegmina, ♂, ♀, 6^{mm}; of hind tibiæ, ♂, 8.5^{mm}; ♀, 9.5^{mm}.

2 ♂, 4 ♀, Southern California, No. 921, H. W. Henshaw; Fort Tejon, California, July 26, No. 905, H. W. Henshaw.

21. *Pezotettix vivax*, nov. sp.—Head large, prominent, yellowish green, mottled with brown, which on the summit forms a very broad longitudinal stripe; vertex between the eyes as broad as the frontal costa, the fastigium slightly sulcate, the frontal costa equal, rather deeply sulcate below the ocellus; antennæ light brown, the basal joint unusually small. Pronotum small, equal, compressed, the dorsum flat, the whole so much smaller than the head as to give the insect a strangulated appearance, brownish

green, mottled with darker and lighter markings, the lateral carinæ with a yellowish stripe and the deflected lobes with a similar oblique stripe descending to the lower anterior angle; the posterior lobe is profusely punctate, the transverse sulci deeply impressed, the median carina obsolescent, the lateral carinæ wholly obtuse, the posterior margin very obtusely angulate; prosternal spine not very stout, cylindrical, very bluntly tipped, inclined rather strongly backward. Tegmina about as long as the pronotum, slender, short, lanceolate; wings rudimentary. Hind femora slender, yellow, tinged on upper half with brownish and obscurely, narrowly, and transversely bifasciate above with the same; hind tibiæ glaucous (?), the spines reddish, tipped with black; arolium extremely large. Abdomen yellowish, tinged above with greenish brown, the last segment of the male scarcely upturned, terminating in a blunt point; anal cerci of male depressed laminate, scarcely longer than the sides of the last dorsal segment, gently incurved, tapering on the basal half, scarcely enlarging beyond, the tip broadly rounded. Length of body, 18.5^{mm}; of antennæ, 9.5^{mm}; of pronotum, 4.25^{mm}; of tegmina, 4.15^{mm}; of hind tibiæ, 9^{mm}.

1 ♂, Plains of Northern New Mexico, eastern slope, October 14–31, Lieut. W. L. Carpenter.

22. *Pezotettix jucundus*, nov. sp.—Yellow, marked with brownish fuscous; top of the head behind the narrowest part of the vertex a little tumid, marked with an elongated, triangular, blackish fuscous dash, through the middle of which runs a yellow line, and by a supraorbital arcuate band of a similar color usually broken and terminating just below a narrow, short, yellow stripe behind the upper part of the eye; vertex between the eyes rather narrower than the frontal costa, the fastigium broadening more than usual in front of the eyes, and longitudinally, broadly sulcate throughout; frontal costa broad and nearly equal, broadest just above the ocellus, rather sparsely punctate, and at the ocellus very shallowly sulcate, often nearly imperceptible. Pronotum short and rather stout, the anterior and posterior halves of the deflected lobes nearly symmetrical; dorsum with equal sides, the posterior lobe scarcely more than half as long as the anterior, the former divided in the middle by a straight sulcus, extending only just beyond the lateral carinæ, and immediately behind this, one-third the distance only to the posterior sulcus, by the sinuate sulcus, which passes across the deflected lobes; the whole anterior lobe slightly gibbous, particularly in the female; the median carina, which is marked with dark brown and is distinct, though slight, on the posterior lobe, is here obsolete, represented only by the dark line, sometimes faintly impressed; the lateral carinæ are very obscure, converging anteriorly, and distinguished by a narrow, dull, yellow stripe, the rest of the dorsum and the upper part of the deflected lobes being obscurely marked with dusky brown, which, on the deflected lobes, is darkest in the sulci; a distinct longitudinal sulcus, more distinct for its deeper color, unites the two percurrent sulci of the deflected lobe in the middle; anterior border marked by a submarginal continuous sulcus, distinct only on the sides; posterior border very broadly rounded or subangulated; prosternal spine straight, rather slender, subconical, bluntly pointed. Tegmina subovate, slightly longer than the pronotum, the apex roundly angulated, the veins mostly of a light color, the middle field furnished with three or four small, quadrate, dark spots in a longitudinal row; wings rudimentary; pleura with an oblique bright-yellow stripe edged with black above the hind coxæ. Outer disk of hind femora marked within the carinæ by a large, apical, yellowish-brown spot, a very broad, angulate, transverse, median band of the same, and a similar basal band, sometimes obsolete or obsolescent, on the lower half; outer arc of genicular lobes black; tibiæ yellow, the apical half of the spines black; arolium either quadrate, rather narrow, longer than the claws (♂), or obpyriform, small, but little more than half as long as the claws (♀). Abdomen yellow, the sides chafed by the femora dark fuscous; the joints of the abdomen of the female are less compressed than usual, and also contracted, and, the appendages being short, it has a peculiarly compact appearance; joints of the male abdomen normal, the last joint upturned, the apex rounded and entire; anal cerci of male very broadly expanded at the base, tapering rapidly and regularly just beyond the middle, beyond less rapidly, forming a delicate, slender, but bluntly pointed tip, slightly hooked downward. Length of body, ♂, 15.5^{mm}; ♀, 17^{mm}; of antennae, ♂, 6.75^{mm}; ♀, 6^{mm}; of pronotum, ♂, 4.1^{mm}; ♀, 4.75^{mm}; of tegmina, ♂, 4^{mm}; ♀, 5.1^{mm}; of hind tibiæ, ♂, 9.25^{mm}; ♀, 10^{mm}.

This species is described from 11 ♂, 10 ♀, collected by Dr. Edw. Palmer at San Diego, Aguas Calientes and Tighes Station in Southern California. A male and female in not so good condition, taken by Dr. O. Loew, near Mojave River in July, No. 870, are larger than the average (♂, 19.5^{mm}; ♀, 18.5^{mm}), and have proportionally longer tegmina (♂, 6.5^{mm}; ♀, 6^{mm}). Especially is this the case with the male; agreeing, however, in all other respects, and having identical anal cerci, there can be little doubt that they belong to this species.

23. *Pezotettix enigma*, nov. sp.—Pale brownish yellow, marked with darker brown and fuscous. Head large, tumid, all the angles rounded, the summit darker, with a sometimes inconspicuous median blackish stripe, broadening from in front backward; vertex between the eyes narrower than (♂) or equal to (♀) the frontal costa; fastigium

very broadly and shallowly sulcate, most distinctly in the male; frontal costa broad and equal, very faintly punctate, with a scarcely perceptible narrow sulcus below the ocellus; antennæ slightly infuscated at the tip. Pronotum shaped as in the preceding species, but more distinctly tumid on the dorsum of the anterior lobe, the middle transverse sulcus nearly as close to the posterior sulcus as to the short one in front of it, and the posterior lobe fully three-quarters the length of the anterior; posterior margin angularly rounded; median carina, as in the preceding species, marked in form like all the transverse sulci; dorsum mottled with dark brown, the lateral carinæ marked with a more or less distinct narrow yellow stripe; the anterior margin of the deflected lobes clear yellow or pallid; prosternal spine straight, small, conical, bluntly pointed. Tegmina rather broad, ovate, overlapping, the tip scarcely produced, fully half as long as the abdomen, brownish fuscous, marked with yellow longitudinal veins, and flecked, principally along the median area, but also elsewhere, with longitudinal series of subquadrate blackish fuscous spots; wings a little shorter than the tegmina. Hind femora stout and full, yellow, the outer face marked with alternate, narrow, angulate, yellow and black stripes, often fainter in parts than in others, so as to show a tendency to transverse bands arranged as in *P. jucundus;* outer arc of genicular lobes broadly black; hind tibiæ yellow, the apical half of the spines black; arolium of either sex as in the preceding species. Abdomen yellow, the upper portion infuscated, the middle of the dorsum marked frequently with a series of approximate, subdorsal, roundish, black spots, often inclosing white spots nearly as large as themselves, those of opposite sides separated only by a slender yellow line; the abdomen of the two sexes has the peculiarities of that of the preceding species, the last joint of the male being also entire; the anal cerci of the male scarcely differ from those of that species, the slender apex only being a little less suddenly contracted. Length of body, ♂, 22.5^{mm}; ♀, 24^{mm}; of antennæ, ♂, 9.25^{mm}; ♀, 7.5^{mm}; of pronotum, ♂ 6^{mm}; ♀, 6.9^{mm}; tegmina, ♂, 8.25^{mm}; ♀, 10.75^{mm}; of hind tibiæ, ♂, 12.5^{mm}; ♀, 13.5^{mm}.

25 ♂, 48 ♀, Santa Barbara, Cal., July 1, No. 1005, H. W. Henshaw; Los Angeles and Santa Barbara, July, No. 224, C. J. Shoemaker.

24. *Pezottetix pictus* Thom.—1 ♂, 1 ♀, plains of Northern New Mexico, eastern slope, October 14–31, Lieut. W. L. Carpenter; Northern New Mexico, August, September, Lieut. W. L. Carpenter. This highly interesting species should be referred to a distinct genus; it is unique in structure and coloration among the species of this group of Acridians.

25. *Hesperotettix viridus* (Thom.) Scudd.—1 ♂, Mojave Desert, California, No. 829, Dr. O. Loew.

26. *Gomphocerus clepsydra* Scudd.—A single female of this species, originally described and hitherto only known from British America, was taken in Southern Colorado June 11–20, Lieut. W. L. Carpenter. 5 ♂ were also taken at the same place and time, and in Northern New Mexico, August to September, by Lieut. W. L. Carpenter. As this sex has not been known, the following description is appended: Head pale brownish yellow, excepting on the summit and sometimes on the cheeks, where it is yellowish brown, more or less tinged with reddish; a pair of moderately broad, arcuate, blackish streaks, sometimes obsolete excepting in front, run from the middle of the summit of the eye to the back of the head above the lateral carinæ of the pronotum; fastigium of vertex depressed, flat, separated from the lateral foveolæ by a distinct ridge, that of one side meeting the other at a little less than a right angle; lateral foveolæ distinct, depressed, forming a slightly arcuate, oblong parallelogram, at least three times as long as broad, the inner extremity rounded; frontal costa a little narrowed above, otherwise nearly equal, punctate, sulcate below and for a slight distance above the ocellus; antennæ more than twice as long as the pronotum, testaceous, the club black, composed of five or six joints, the middle ones but slightly larger, though much more depressed, than those of the stalk. Pronotum dark yellowish brown, the lateral carinæ as distinct as the median carina, arcuate, twice as close together just in advance of the middle as at the posterior extremity, pallid, edged exteriorly and especially in front with black, and interiorly on the posterior lobe with the same; lower portion of deflected lobe with an anterior blackish triangle, the longest side facing upward and forward, followed behind by a slender yellowish stripe, directed a little downward and sometimes edged above with black. Tegmina reaching the tip of the abdomen with the costal field broad, pellucid, the nervules scalariform; the remainder testaceous, with minute faint fuliginous clouds in the more or less pellucid middle field. Hind legs long and slender, the femora generally more or less marked longitudinally with black along the upper exterior carina. Sides of the abdomen marked with black on the basal half of each segment. Length of body, 18^{mm}; of antennæ, 9^{mm}; of pronotum, 4.1^{mm}; of tegmina, 12.85^{mm}; of hind tibiæ, 12^{mm}.

This species seems to be allied to *G. clavatus* Thom., but differs from the description of that species in many important particulars.

27. *Gomphocerus navicula*, nov. sp.—Pale dull brownish yellow, the upper surface of the head and pronotum darker; summit of the head with a delicate, straight, black

line running from midway between the extreme summit of the eye and the medio-dorsal carina to the back of the head, midway between the dorsal and lateral carinæ, and edged within by an entirely similar yellowish or roseate line; both these lines scarcely taper anteriorly; there is a slight but distinct medio-dorsal carina extending from the back of the head through the fastigium, where it is more distinct, to its very tip; the lateral carinæ of the fastigium are equally distinct, and together form a U; lateral foveolæ wanting; frontal costa slightly narrowed above, otherwise nearly or quite equal, punctate, below the ocellus a little sulcate; antennæ less than twice as long as the pronotum, brown, the club duskier, made up of seven or eight joints, occupying fully a quarter of the antennæ, fusiform, and in the male distinct. Pronotum with the lateral carinæ as distinct as the median carina, a little arcuate, only a fifth nearer each other a little in advance of the middle, than at the posterior border, pale yellow, narrowly edged within throughout and without in the middle with black; sides of the deflected lobes with an arcuate, yellow, black-edged streak extending a little below the middle from the anterior sulcus to the hind border. Tegmina extending to the tip of the abdomen, the costal field (♂) somewhat expanded beyond the middle, with oblique subscalariform nervules, the remainder (♂ ♀) testaceous, with longitudinal fuscous, subconfluent streaks in the middle area; wings with the apical nervures slightly thickened and blackish. Hind femora moderately slender, the upper outer carina more or less edged beneath with blackish fuliginous; tibiæ yellow, with spine black on the apical half. Length of body, ♂, 14.75^{mm}; ♀, 18.5^{mm}; of antennæ, ♂, 5.5^{mm}; ♀, 5.4^{mm}; of pronotum, ♂, 3.25^{mm}; ♀, 3.8^{mm}; of tegmina, ♂, 10.5^{mm}; ♀, 12.5^{mm}; of hind tibæ, ♂, 8^{mm}; ♀, 9^{mm}.

2 ♂, 1 ♀, Southern Colorado, June 11–20, Lieut. W. L. Carpenter; Northern New Mexico, August to September, Lieut. W. L. Carpenter.

This species bears most resemblance, among species known to me, to the preceding, from which it is readily distinguished by the much shorter antennæ, the want of lateral foveolae on the vertex, and the lesser curvature of the lateral carinæ of the pronotum.

28. *Dociostaurus ornatus*, nov. sp.—Pale brown, above darker; an arcuate row of fuscous dots from the posterior extremity of the fastigial carinæ to the back of the head midway between the dorsal and lateral carinæ of prothorax, and a similar straight row from the middle of the posterior edge of the eye backward; fastigium rather deeply sulcate posteriorly with a low median carina, the lateral carinæ prominent, meeting at an acute angle in front; lateral foveolæ very distinct, pretty large, subquadrate, a little longer than broad, the lower edge horizontal; frontal costa much narrowed above, nearly equal below, shallowly but broadly and abruptly sulcate throughout, and punctuate; antennæ dark brown, becoming duskier toward the tip, the apical joints slightly enlarged. Pronotum slightly convex anteriorly, broadly angulated posteriorly, the lateral carinæ as distinct anteriorly as the median carina, thickened posteriorly, very strongly arcuate, so as to be fully twice as distant at the posterior border as a little in advance of the middle, edged outwardly with black on the anterior lobe and front part of posterior lobe, and interiorly more broadly on the front part of the posterior lobe; deflected lobes, marked with dark colors and especially with a subcentral, quadrate, blackish fuliginous spot. Tegmina longer than the body, the costal area subpellucid, the rest testaceous, with a longitudinal row of conspicuous fuliginous and blackish fuliginous spots in the median area. Hind femora sparsely dotted externally with blackish fuscous along the edges, above showing signs of clustering into spots, and on the upper surface a median spot crossing the upper carina and bordered distinctly with black on the outer side; there is also an oblique black basal streak, and an apical and subapical fuscous spot; hind tibiæ clear pale yellow, the spines black-tipped. Length of body, 12.5^{mm}; of antennæ, 5.3^{mm}; of pronotum, 2.6^{mm}; of tegmina, 11.8^{mm}; hind tibiæ, 7.1^{mm}.

1 ♂, Northern New Mexico, August to September, Lieut. W. L. Carpenter.

In North America, the *Œdipodidæ* are far more abundantly represented than any other group of Acridians. The present collection is rich in novel forms, and affords also the opportunity of continuing my efforts to reduce the known species to symmetrical relations. The following table, partly based upon that by Stål (Recens. Orthopt., I), has accordingly been prepared for the readier determination of the genera; it is intended, however, to apply only to the genera mentioned in this paper, and even only to such species of these genera as are catalogued. Doubtless, it may have a wider application but in its preparation no species were examined but those mentioned below.

1 (30) Opposite tegmina attingent when closed.
2 (23) Median carina of pronotum, with a single submedian incision.*
3 (12) Mesosternal lobes of female nearly or fully twice as distant as the metasternal lobes.
4 (9) Median carina of pronotum much more elevated than the lateral carinæ.
5 (6) Hind border of pronotum very obtusely rounded....... *Œdocara.*
6 (5) Hind border of pronotum bent at a right angle or less.
7 (8) Intercalary vein of tegmina running through the middle of the postradial area........................ *Chimarocephala.*
8 (7) Intercalary vein of tegmina approaching the radial apically, *Arphia.*
9 (4) Lateral carinæ of pronotum nearly or quite as elevated as the median carina.
10 (11) Axillary vein of tegmina free................ *Stirapleura.*
11 (10) Axillary vein joining the anal vein in the basal half of the tegmina.................................... *Psoloessa.*
12 (3) Mesosternal lobes of female scarcely or not at all more distant than the metasternal lobes.
13 (16) Median carina of pronotum very inconspicuous; axillary vein ot tegmina uniting with the anal without branching.
14 (15) Tegmina with a close, irregular reticulation on the basal four-fifths.................................. *Hadrotettix.*
15 (14) Tegmina with a close, irregular reticulation on the basal fourth only....................................... *Anconia.*
16 (13) Median carina of pronotum distinct, sometimes very prominent; axillary vein of tegmina free or branching before joining the anal vein.
17 (18) Median carina of pronotum uniform throughout.... *Camnula.*
18 (17) Median carina of pronotum irregular.
19 (20) Pronotal carina nearly obsolete on posterior portion of anterior lobe..................................... *Hippiscus.*
20 (19) Pronotal carina crested on anterior lobe.
21 (22) Dark band of wings extending nearly or quite to the base... *Dissosteira.*
22 (21) Dark band of wings only as broad as, or but little broader than, the tegmina.......................... *Œdipoda.*
23 (2) Median carina of pronotum with a deep secondary incision. [See, however, note under 2 (23).]
24 (25) Summit of head conspicuously rugulose, or furnished with sharp transverse carinæ............................ *Trachyrachys.*
25 (24) Summit of the head with the usual configuration.
26 (27) Axillary vein joining the anal in the basal half of the tegmina, *Psinidia.*
27 (26) Axillary vein terminating on the hind border of tegmina.
28 (29.) Posterior lobe of pronotum scarcely longer than the anterior, *Derotmema.*
29 (28.) Posterior lobe of pronotum nearly twice as long as the anterior *Trimerotropis.*
30 (1) Closed tegmina separated by more than their own width .... *Brachystola.*

29. *Chimarocephala viridifasciata* (De Geer).—3 ♂, 1 ♀, were taken in Southern Colorado, June 11–20, and in Northern New Mexico in August and September by Lieut. W. L. Carpenter. In the cloudiness of the wings, they agree best with Texan specimens as described in my Entomological Notes (IV, 81). The generic name (χίμαρος, κεφαλή) is proposed for the species (*viridifasciata, brevipennis, cubensis, pacifica*) placed by me (*loc. cit.*) under *Tragocephala;* the latter name, as M. Auguste Sallé has pointed out to me, being pre-occupied in *Coleoptera* (Dupont, 1834).

30. *Psoloessa maculipennis* Scudd.—2 ♀, Southern Colorado, August to September, Lieut. W. L. Carpenter.

31 *Arphia teporata*, nov. sp.—This red-winged species is so nearly allied to *A. frigida* Scudd., of the high north, that it need only be compared with it; the upper extremity of the frontal costa of the head has no transverse carina setting off a pair of minute frontal foveolæ; the fastigium of the vertex is very slightly narrower. The tegmina are

* The single species of *Hippiscus* mentioned below has the anterior lobe slightly impressed by a transverse sulcus, and in specimens dried after soaking in alcohol such an impression may be accidentally intensified. In *Hadrotettix* and *Anconia* there is a slight transverse sulcus near the middle of the anterior lobe, which in *Anconia*, and sometimes in *Hadrotettix*, severs the carina, but so slightly that I have placed the genera in this division.

slightly narrower and are flecked almost uniformly throughout with fuscous dots, smaller and a little less frequent on the apical third; entire inner area pale yellowish testaceous; wings with a transverse band, and base exactly as in *A. frigida*, but with the entire apex uniformly pellucid, obscured only by the blackish veins. Hind tibiæ glaucous, with a very broad pale yellow annulation at the base, and a slight testaceous tinge at extreme tip; the apical half of spines black. Length of body, ♂, 19^{mm}; ♀, 28.2^{mm}; of antennæ, ♂, 8^{mm}; ♀, 7.5^{mm}; of pronotum, ♂, 4.5^{mm}; ♀, 6.25^{mm}; of tegmina, ♂, 19^{mm}; ♀, 26.5^{mm}; of hind tibiæ, ♂, 8.8^{mm}; ♀, 12.5^{mm}.

2 ♂, 2 ♀, Southern Colorado, June 11–20, and Northern New Mexico, August to September, Lieut. W. L. Carpenter. I have also received the species from Pecos River, Texas, Captain Pope.

32. *Camnula atrox* (*Œdipoda atrox* Scudd.; *Camnula tricarinata* Stål). A considerable number of specimens were taken in Southern California; at Santa Barbara, June, No. 885, C. J. Shoemaker; June 10, Dr. O. Loew; July 1, No. 1005, H. W. Henshaw; in the Mojave Desert, July, No. 935, Dr. O. Loew; and on Santa Cruz Island, in June, No. 967, H. W. Henshaw. I have also received it from other points in California, viz: from Tighes Station, and Julian, in the southern part of the State, Dr. E. Palmer; and from Santa Rosa Island, Central California, Nevada, and Vancouver's Island, Henry Edwards, esq. This material shows that the species varies greatly in the markings of the tegmina. The usual distribution of the fuscous spots seems to be the following: the middle area is filled with large, transverse, quadrate spots, separated by rather narrow interspaces; those on the basal half of the wings more or less confluent, particularly below. On the outer half, they become smaller and less conspicuous toward the tip, and are usually confined to a couple of patches, somewhat curtailed beneath in the third quarter of the wing and scattered dots beyond; besides these, there is, usually, a small, oblique, subquadrate, dark fuscous spot on the costal border, just beyond the highest point of the costal arch, and near the middle of the same border two or three short oblique streaks. Not infrequently, however, all these markings are much reduced, the quadrate spots become rounded, and the result may be simply a series of three or four subequal, round, fuscous spots in the median area, some scattered dots beyond them, and slight touches along the costal border; or there may be a couple of narrow, transverse streaks at and beyond the middle of the wing, made up of clustered dots, with one or two dots beyond, a small, quadrate, longitudinal spot in the middle of the basal half of the middle area, and a small spot at the costal arch.

33. *Hippiscus corallipes* (Hald.) Scudd.—1 ♀, Southern Colorado, June 11–20, Lieut. W. L. Carpenter.

ŒDOCARA, (*οἰδέω, κάρα*), *nov. gen.*

Allied to *Œdaleus*. Head large and tumid, the face vertical; vertex between the eyes twice as broad as the frontal costa; the anterior half of the fastigium suddenly contracted to about one-third its previous width, the lateral carinæ prominent; lateral foveolæ very distinct, with prominent walls, pretty large, triangular, pointed interiorly; frontal costa rather strongly contracted above, a little expanded at the ocellus, somewhat sulcate throughout and especially just below the ocellus; eyes rather small, not very prominent; antennæ about as long as the hind tibiæ, the joints of the basal half a little depressed. Pronotum small, greatly constricted in the middle, scarcely longer than the head, the anterior and posterior lobes of nearly equal length; the constriction is nearly confined to the anterior lobe, which is furnished posteriorly with two deeply-impressed transverse sulci, extending (deeply) a short distance into the deflected lobes, and extending up to, but not traversing, the median carina; this is of equal and slight elevation throughout, and the lateral carinæ are present only as a shoulder to the flat posterior lobe; the anterior lobe, on the other hand, is nearly tectiform, and its anterior border is full and rounded, expanding slightly upon the surface of the head; posterior border very obtusely and roundly angulated; pleura of metathorax carinate, especially below. Tegmina extending beyond the abdomen, the costal margin considerably expanded in the middle of its basal half; the intercalary vein rather inconspicuous, minutely tortuous, dividing the postradial field; axillary vein free. Hind femora moderately slender, with sharp, unarmed, superior carina; interior, apical, curved spines of hind tibiæ subequal.

34. *Œdocara strangulatum*, nov. sp.—Yellowish brown, the face and cheeks paler, and, like the top of the head, profusely mottled with small, darker fuscous spots; antennæ pale, the apical third blackish fuscous. Dorsum of pronotum pallid, the posterior lobe, excepting a broad, lateral, pallid stripe along the carinæ, reddish brown and punctate, a quadrate patch of the same color on the upper half of the deflected portion of the anterior lobe. Tegmina dead brown, the inner edge paler, the rest rather sparsely and almost uniformly flecked with small brownish spots; wings pellucid; most of the veins of the outer half of the front portion black. Hind femora with two oblique bars of reddish brown, crossing the upper half of the outer face and the upper face, the distal one also traversing, not obliquely, the inner face; a few dots of the same color fleck the lower outer carina; upper half of the outside and whole of the inside

of the genicular lobes black; tibiæ pale yellow, fuscous at extreme tip, the apical half of spines black. Length of body, 21.5^{mm}; of antennæ, 11^{mm}; of pronotum, 4.1^{mm}; of tegmina, 20^{mm}; of hind tibiæ, 11.75^{mm}.

1 ♀, 7 pupæ, Southern Colorado, June 11–20, Lieut. W. L. Carpenter.

STIRAPLEURA (*στεῖρα, πλευρά*), *nov. gen.*

Allied to the preceding. Head moderately large, the face vertical; vertex between the eyes rather broader than the lower extremity of the frontal costa; fastigium depressed, with very high and sharp bounding-walls, which are parallel through most of their course, incline slightly toward each other as they disappear posteriorly, and bending sharply in front meet at a right angle; lateral foveolæ rather large and distinct, with high walls, the posterior at right angles to the inferior and but little shorter, the other portion of the wall forming a sharply arcuate hypothenuse of the triangle; frontal costa strongly compressed above, expanding to near the ocellus, then parallel, and below the ocellus again expanding, throughout sulcate; eyes of medium size, not very prominent; antennæ (♀) slightly depressed, short, scarcely reaching the tip of the pronotum. Pronotum small, slightly constricted in the middle, the posterior slightly longer than the anterior lobe, the dorsum nearly flat, the median carina undivided on the anterior lobe, equal and slight throughout, the lateral carinæ similar but strongly arcuate; posterior margin bent at slightly more than a right angle, the angle rounded; pleura of metathorax with a distinct sharp carina on the outer face, extending from the edge of the coxæ close to the edge of the closed tegmina. Tegmina extending beyond the tip of the abdomen, the costal area slightly expanded at the end of the basal third, the intercalary and axillary veins as in *Œdocara;* wings rather ample. Hind femora moderately slender and short, scarcely reaching the tip of the abdomen, with superior carina unarmed.

35. *Stirapleura decussata*, nov. sp.—Wood-brown above, paler below; face and mouth parts tinged with yellow, the former flecked with reddish brown; antennæ yellowish brown; behind the eye a broad, dark band, expanding posteriorly, deepening into black above and edged with pallid yellow, extends to the pronotum. Lateral carinæ of pronotum a little paler than the disk, especially on the posterior lobe, where a distinct yellowish band follows its interior border, edged on either side by velvety black, followed by reddish brown; more or less of the velvety black follows the inferior edge of the carinæ anteriorly and the anterior and posterior borders of the deflected lobes; are distantly dotted with it; on the anterior section of the deflected lobe next to the lateral carinæ, the dark-brown postocellar band continues; just below it are some short longitudinal rugæ, and across the middle of the deflected lobe a second dark-brown band extends horizontally and a little arcuate, inclosing just behind the middle a small crescentic yellow spot. Tegmina dotted rather profusely, excepting at the extreme tip, with small, unequal, fuscous spots; wings pellucid, most of the veins in the apical half of the expanded wing black. Hind femora, with basal, median, and post-median dark-brown streaks on the upper half of the outer surface of the wing, growing more oblique apically, and connecting on the upper face with more distinct, triangular, transverse blotches, with darker edges, the inferior outer carina dotted with blackish fuscous; hind tibiæ yellow, a little infuscated at extreme tip, the spines black on the apical half. Length of body, 19^{mm}; of antennæ, 5.5^{mm}; of pronotum, 3.5^{mm}; of tegmina, 16^{mm}; of hind tibiæ, 9.2^{mm}.

1 ♀, Southern Colorado, June 11–20, Lieut. W. L. Carpenter.

36. *Phlibostroma parvum*, nov. sp.—Dull brown; the face infuscated; antennæ pale yellowish brown, a little infuscated at the extreme tip. Pronotum with the same dark markings as in *P. pictum* Scudd., the posterior margin with the angle a very little less rounded. Tegmina scarcely reaching the tip of the abdomen, pale cinereous, with four large, equidistant, rounded, triangular, fuscous spots, darkest on the edges, seated upon the ulnar veins, the middle ones larger than the outer; wings hyaline, the veins at the apex blackish. Hind legs as in *P. pictum*. Length of body, 14.5^{mm}; of antennæ, 9^{mm}; of pronotum, 3.5^{mm}; of tegmina, 9.5^{mm}; of hind tibiæ, 8.8^{mm}.

1 ♂, plains of Northern New Mexico, eastern slope, October 14–31, Lieut. W. L. Carpenter.

This species closely resembles the one formerly described under the name of *P. pictum*, but differs strikingly from it in the shortness of the tegmina and wing, which in *P. pictum* reach far beyond the tip of the abdomen; in both, though it is not mentioned in the description of either species, the tegmina have a longitudinal series of equidistant fuscous points just above the radial veins. The genus resembles more closely *Œdaleus* Fieb., than *Psinidia* Stål, to which I compared it, and, like several genera in its vicinity, but perhaps more than most of them, bears a striking resemblance to the *Stenobothri*.

37. *Œdipoda venusta* Stål.—2 ♂, 1 ♀, Santa Cruz Island, Cal., June, No. 853, Dr. O. Loew; Los Angeles and Santa Barbara, Cal., July, No. 224, C. J. Shoemaker.

To this species with little hesitation I refer one of the specimens obtained on Santa Cruz Island, although it differs in some points from another specimen from that island,

and from those received from the neighboring main (the above and San Diego, Dr. E. Palmer), particularly in the narrowness of the dark mesial band of the hind wings, which nowhere even appears to meet the hinder margin, and in the obscurity of the marking of the tegmina.

One specimen from Los Angeles has one antenna shorter than the other, and both much shorter than usual, although not broken; they were doubtless injured in early life and reproduced in an atrophied form; the apical joint of the longer antenna is half divided beyond the middle.

Stål's limitation of the genus *Œdipoda*, in his Recensio Orthopt., I, forces us to consider *Gryllus cœrulescens* Linn., as the type, and not, as stated by Thomas, *Œdipoda carolina* (Burm.). On this basis the genus is but feebly represented in the United States, and by species which differ considerably from the type. The nearest ally to *Œd. cœrulescens* is the species just recorded, in which the intercalary vein is much more closely approximated to the radials, the anal vein is connected with the axillary only by one of its branches, and the apical fourth of the tegmina is free from the intricate network of the middle of the same; the pronotal carina is also much more elevated anteriorly.

Next in position to this group, in their relation to the true *Œdipodæ*, are, in this country, *Œdipoda carolina* (Burm.) and *Œdipoda trifasciata* (Say), which are also included in the genus by Stål. The points wherein they differ, and upon which distinct genera should be based, will be given under the generic names *Dissosteira* and *Hadrotettix*, next following.

DISSOSTEIRA (δισσός, στεῖρα), *nov. gen.*

This genus, of which *Gryllus carolinus* Linn. is the type, differs from the true *Œdipoda*, as represented by *Gryllus cœrulescens* Linn., in the following points: The head is more prominent, the vertex being elevated and tumid; the antennæ of the male do not thicken before, and taper at, the tip; the front of the fastigium terminates, as in *Trimerotropis*, by an angulate depression, and not by a straight transverse ridge; the vertex is somewhat broader between the eyes, and the latter in the male are rounder. The enlargement of the pronotum is wholly confined to the posterior lobe; the median carina is greatly elevated, and that of the posterior lobe much arched; the metasternal lobes of the male are scarcely less distant than the mesosternal lobes. The tegmina are freer from the fine network of veins over a much larger part of the apex; all the veins are more prominent, and the anal vein is free from the axillary; the anal area of the wings is deeper, nearly or quite reaching the tip of the abdomen; the species are all insects of large size.

In very many of these points it will hardly fail to be noticed that this group approaches much more closely the American than the gerontogeic section of *Œdipoda*. *Œdipoda nebrascensis* Brun. and the following species also belong to this genus.

38. *Dissosteira longipennis* (*Œdipoda longipennis* Thom.).—1 ♂, plains of Northern New Mexico, eastern slope, October 14–31, Lieut. W. L. Carpenter.

HADROTETTIX (ἁδρός, τέττιξ), *nov. gen.*

This group agrees with the typical *Œdipodæ* in the general structure of the tegmina, but differs in the comparative length of the anal area and the point of junction of the anal and axillary veins, and offers several other points of contrast; the whole body is stouter; the lateral foveolæ of the vertex are obsolete; the antennæ are uniform in size throughout in the male, and in both sexes are longer and much stouter. The hind lobe of the pronotum is slightly tumid, the median carina nearly obliterated (in which it differs strikingly from *Dissosteira*), and the lateral carinæ obtuse; the metasternal lobes of the males, instead of being only half as far apart as the mesosternal lobes, are very nearly as far apart, much as in the females in both genera; the inferior carina of the hind femora is also much broader.

39. *Hadrotettix trifasciatus* (*Gryllus trifasciatus* Say).—, 1 ♀, Northern New Mexico, August to September, Lieut. W. L. Carpenter.

TRACHYRHACHYS (τραχύς, ῥάχις), *nov. gen.*

Allied to *Trilophidia* Stål. Head pretty large, broadening very slightly below; summit more or less rugose; the space between the eyes equal to the width of the eyes; the quadrate fastigium bounded by sharply-elevated carinæ, which run parallel to each other at the sides, but in front suddenly incline toward each other, but do not meet, leaving a deep sulcus between their separated tips; the fastigium is deeply depressed; lateral foveolæ rather large, triangular, deeply hollowed; frontal costa sulcate throughout, expanded slightly at extreme summit between the lateral foveolæ, just below it constricted, expanding again slightly at the ocellus, below which it is again, though very slightly, constricted, and then expands; eyes small, moderately prominent; antennæ slightly depressed, a little shorter (♀) than the hind tibiæ. Pronotum moderately small, the posterior lobe a little longer than the anterior, the disk rugose, the median carina moderately high, equal, compressed, on the anterior lobe severed behind the middle, and the portion between the two sulci accompanied by closely-approximated, nearly as elevated, more or less irregular, subdorsal carinæ, sometimes connected by a ridge with the median carina; posterior border rectangular;

anterior border slightly produced and angulate. Tegmina straight, the intercalary vein traversing the middle or near the middle of the postradial area, the axillary connected at its tip with the anal vein. Hind femora broad, rather short, the upper and lower carinæ elevated, the former suddenly decreasing near the middle of the apical half of the leg.

The callosities of the head and pronotum, and the structure of the hind femora, separate this genus from any other American group known to me. *T. coronata* Scudd., may be considered the type.

40. *Trachyrhachys aspera*, nov. sp.—Summit of the head between the middle of the eyes and backward furnished with many parallel approximate series of transverse rugæ, divided longitudinally by a pair of slight and inconspicuous subdorsal sulcations; fastigium with a very deep median transverse sulcation, in front of the middle of which is a minute tubercle; frontal costa deeply sunken between the lateral foveolæ; sulcus below this uninterrupted; whole head profusely punctulate. Subdorsal carinæ of the posterior portion of the anterior lobe of pronotum regularly crescentic, opening inward, posterior margin of the pronotum sharply angled. Light yellowish brown; summit of the head fuscous; a dark fuscous stripe crosses the eye from the lateral carinæ of the face to the back of the head, broad and directed downward in front of the eye, slender and horizontal behind it; the lower posterior corner of the cheeks are also dusky, and the middle of the face is more or less obscured with it; basal half of the antennæ of the general color, beyond deepening into dark fuscous. Pronotum more or less infuscated, especially on the posterior lobe and on the subdorsal carinæ of the disk, the anterior lobe next the ocellar stripe of the head, and the neighborhood of a short, rather broad, oblique dash of yellow on the lower posterior part of the deflected lobe. Tegmina just reaching the tip of the abdomen, flecked with fuscous, mostly collected into median, post-median, and costal spots on the anterior half of the tegmina, the latter in the middle of the basal half, the lower apical third subhyaline; wings hyaline (perhaps faint yellow on the basal half), with an arcuate, moderately broad, fuliginous belt, traversing the middle of the apical two-thirds, in the preanal area sending a broad, tapering shoot almost to the base, and accompanied by a few dusky fleckings at the apex, and a blackish fuliginous costal stigma, nearly half as long as the wing, from the middle of the wing outward. Hind femora with very obscure, broad, oblique, basal, and median brownish stripes on the outer face, and, on the upper face, basal, median, and post-median, darker, oblique, reversed blotches, edged with blackish; hind tibiæ yellowish, with a broad, apical, dark fuscous cloud; apical half of the spines black. Length of body, 23^{mm}; of antennæ, 8^{mm}; of pronotum, 4.5^{mm}; of tegmina, 16.7^{mm}; of hind tibiæ, 9.5^{mm}.

1 ♀, plains of Northern New Mexico, eastern slope, October 14–31, Lieut. W. L. Carpenter.

41. *Trachyrhachys coronata*, nov. sp.—Fastigium of the vertex bounded behind as well as in front by an oblique extension of the lateral carinæ, which fork at the posterior limit of their parallel course; behind this the summit of the head is furnished with moderately conspicuous, oblique rugæ parallel to the posterior bounding ridge of the fastigium, the anterior set broken into tubercles; middle of the fastigium with a transverse, bent carina, as high as, and parallel to, the anterior bounding ridge of the same; behind the middle of the lozenge-shaped space posterior to it is a tubercle; the carinæ of the frontal costa extend briefly into the front of the fastigium; in the middle of the expanded portion of the frontal costa, between the lateral foveolæ, is a slight longitudinal tubercle, and next the upper edge of the ocellus a transverse ridge breaking the sulcus. The subdorsal carinæ of the posterior portion of the anterior lobe of the pronotum are irregular in height and direction, but in general their highest point, with the slight elevations of the median carina on either side of the anterior sulcus, form a sort of quadrilateral; the rugosities of the disk of the pronotum are more elevated than in the preceding species, and more or less confluent, forming sharp, tortuous carinæ; posterior margin of the pronotum slightly sinuous on the sides, the angle rounded. Pale cinereous, the markings of the head, thorax, and hind femora much obliterated by the mode of preservation of the single individual before me, but apparently as in the preceding species, excepting that the yellow dash on the deflected lobe of the pronotum is near the center of the lobe, short, small, and horizontal, with a dusky quadrate cloud above it. Tegmina extending much beyond the tip of the abdomen, cinereous, profusely sprinkled with large, roundish, dark fuscous patches, edged with black; in the costal area are five such equidistant spots, the innermost next the base a mere dot, the next united to the basal spot of the median area, the inner edge of the third and largest lying just beyond the costal angle; the median area has seven or eight such spots, equidistant, growing larger until close to the tip, the second and third from the base roundish, those beyond triangular or transverse and less distinct; the ulmar veins are yellowish, and below them is a basal cloud and a post-basal, rhomboid, pale fuscous spot; wings pale yellow at base, hyaline at tip, with a pretty broad, blackish fuliginous, arcuate band extending across the wing and curving next the border to the anal angle, its inner border crossing the middle of the wing; it sends a broad, tapering, rather abruptly terminating shoot half-way to the base in the preanal area, and just

beyond it on the costal margin is a whitish stigma extending nearly half-way to the tip of the wing; veins at apex black. Length of body, 24mm; of antennæ, 9.25mm; of pronotum, 4.6mm; of tegmina, 22.5mm; of hind femora, 10mm.

1 ♀, Northern New Mexico, August to September, Lieut. W. L. Carpenter.

42. *Psinidia sulcifrons*, nov. sp.—Very pale cinereous; upper half of the head, but especially the summit, sprinkled with blackish fuscous dots, and behind the eye a short, rather broad, longitudinal fuscous bar; summit of head much depressed between the eyes, and scarcely so broad as their width when seen from above; antennæ of male scarcely as long as the hind tibiæ, fuscous on the apical half. Median carina of pronotum not very elevated, nearly equal, the posterior portion of the anterior lobe very short, transversely corrugated; posterior lobe transversely rugose and punctate; the lateral carinæ with a narrow, blackish, fuscous stripe, in continuation of that on the head, the deflected lobe with an anterior, mesial, quadrate, blackish fuscous patch. Tegmina extending much beyond the tip of the abdomen, flecked with blackish dots at the extreme base, especially on the costal and anal fields, beyond with two large quadrate, blackish fuscous, costal patches, infringing a little on the median field, one in mid-wing, the other in the middle of the basal half; the apical half of the tegmina are nearly pellucid, especially in the middle field, with hoary veins; but it is flecked with a few dark fuscous dots, mostly clustered into minute equidistant spots, near, but not upon, the upper and lower borders; wings pellucid, the base suffused very faintly with lemon as far as the arcuate belt, which crosses the middle of the wing; the belt is moderately broad, reaches the lower border, but does not extend far toward the anal angle, and in the preanal area sends a rather slender tapering shoot nearly half-way to the base; all the veins and cross-veins of the wing are yellowish white, excepting at the extreme tip and next the costal margin, where they are black; the uppermost radial of the anal field is also black. Length of body, 18.5mm; of antennæ, 9.75mm; of pronotum, 3.8mm; of tegmina, 21.5mm; of hind tibiæ, 10mm.

1 ♂, near Mojave River, Southern California, July, No. 870, Dr. O. Loew. In several particulars, but especially in the brevity of the antennæ, this is rather an aberrant member of the genus *Psinidia*.

DEROTMEMA, (*δηρός, τμῆμα*), *nov. gen.*

Closely allied to *Psinidia*. Head of moderate size, the face a little oblique, sharply ridged, the eyes large, globose, very prominent, farther apart above than twice the extreme width of the basal joint of antennæ; fastigium of vertex very deeply channeled, with exceedingly high, sharply-compressed, lateral carinæ, which, as soon as they have left the edge of the eyes, bend toward each other at an acute angle, closely approximate, and continue distinctly down the face as lateral raised edges of the frontal costa; summit of head with a slight median carina, which at the extreme front of the fastigium divides and strikes against the lateral carinæ; directly at this fork commences a deep sulcus, which unites uninterruptedly with that of the frontal costa; this costa, expanding a little at the ocellus, again contracts slightly, and then expands greatly; the lateral carinæ of the face equally prominent with, and parallel to, the borders of the frontal costa; antennæ very long, depressed cylindrical, with elongated joints. Pronotum much as in *Psinidia*, the median carina quite the same; surface of disk rugose, the posterior border rectangular. Tegmina reaching beyond the tip of the abdomen, straight, the costal shoulder rather prominent and angular; the intercalary vein is prominent, and runs along the middle of its area; the axillary vein is free, though occasionally united at its tip with the anal vein by a cross-nervure; meso- and metasternum about equally distant in the male. Hind femora extending beyond the tip of the abdomen, rather slender, the carinæ very moderate; arcuate, apical, inner spurs of hind tibiæ equal.

43. *Derotmema cupidineum*, nov. sp.—Cinereo-fuscous, darkest above; a slender, black band unites the middle of the eyes in front, directly above the base of the antennæ; a similar black or blackish stripe unites the middle of the eyes above, on the summit, traversing the fastigium; besides which, there is a more or less distinct, median, longitudinal, black stripe on the summit, and an arcuate black stripe back of the upper part of the eye; antennæ pale toward the base, blackish fuscous toward the tip, and, excepting at the tip, the alternate joints paler, giving them an annulate appearance. Posterior portion of anterior lobe of pronotum with subdorsal crescentic carinæ, much as in *Trachyrhachys aspera;* posterior edge of pronotum dotted with black; center of deflected lobes with a small, quadrate, black spot. Tegmina with the middle field nearly immaculate, the others with blackish fuscous spots linearly arranged, most abundant and most distinct on the basal two-thirds; wings lacteous at base (yellowish in life?) with a rather strongly arcuate, moderately broad, blackish fuliginous band, its inner edge crossing the middle of the wing, extending along the lower margin halfway to the anal angle, and in the preanal area sending a moderately broad, long, tapering shoot more than half-way to the base; the band is slightly obsolescent along the ulnar veins; the apex of the wing is pellucid, with blackish cross-veins, often edged with a fuliginous cloud, especially on either side of the ulnar vein apically. Hind femora with faint fuscous basal, median, and post-median blotches on the upper surface,

and a few dusky dots along the inferior outer carina; hind tibiæ pale reddish, (?) the spines tipped with reddish fuscous. Length of body, 13mm; of antennæ, 10.5mm; of pronotum, 3mm; of tegmina, 15.75mm; of hind tibiæ, 8mm.

2 ♂, Northern New Mexico, August to September, Lieut. W. L. Carpenter.

44. *Trimerotropis obscura*, nov. sp.—Pale brownish cinereous, the under surface and mouth-parts paler; head dotted profusely, pronotum less profusely, with blackish specks; an inconspicuous dusky stripe behind the middle of the eye; antennæ nearly as long as the hind tibiæ, annulate with pallid and fuscous. Deflected lobes of pronotum with a very small blackish or fuscous, central, longitudinal bar. Tegmina sprinkled profusely with blackish fuscous dots, partially collected into three, equidistant, indistinct, dusky clouds, the middle one in the middle of the wing; wings pale yellowish at base, beyond the middle with a very broad fusco-fuliginous band, in the preanal area sending a broad, tapering, rather bluntly-terminating shoot more than half-way toward the base; the inner margin of the band otherwise scarcely arcuate, at the lower margin scarcely extended toward the anal angle; apex of the wing faintly fuliginous, the veins blackish. Hind femora with exceedingly faint, dusky, broad, transverse, oblique bands on the outer face, made more distinct on the upper surface by a sprinkling of black dots, which also mark the inferior outer and inferior carinæ; hind tibiæ of the color of the femora, infuscated at tip, the spines black, excepting at base. Length of body, 27mm; of antennæ, 12mm; of pronotum, 6.5mm; of tegmina, 29mm (?); of hind tibiæ, 13mm.

1 ♀, Northern New Mexico, August to September, Lieut. W. L. Carpenter.

This species in its coloration, and especially in the broad band of the wings, has much the aspect of an *Arphia*. The single specimen obtained is somewhat mutilated, but it is so distinct from any species known to me that I venture to describe it.

45. *Trimerotropis pseudofasciata*, nov. sp.—Brownish cinereous, more or less dotted with fuscous, the middle of the deflected lobes of the pronotum with a quadrate, blackish spot, followed beneath by yellowish; antennæ more or less distinctly annulate with fuscous. Tegmina extending far beyond the tip of the abdomen, with two transverse, blackish, fuscous bands, one median, the other in the middle of the basal half, tapering anteriorly, the inner edge of the inner one usually distinct, and always followed basally by a profuse sprinkling of fuscous dots; apical two-fifths similarly sprinkled, but with slightly larger quadrate spots, often irregularly clustered into spots, nearly or quite as conspicuous in the middle area as toward either border; wings very pale yellow at base, beyond pellucid, with a faint, slightly irregular, subarcuate. mesial band, made up altogether of the darkening (to blackish fuliginous) of the veins of this portion, and occasionally by a slight smokiness of the neighboring cells; the veins of the apex of the wing are again darkened, though not to so great an extent. Hind femora with three obscure, brownish, transverse, oblique belts on the outer face, sparsely sprinkled with blackish dots, becoming more distant, though still not very conspicuous, on the upper face; hind tibiæ yellow, fully one-half of the spines black apically. Length of body, ♂, 20mm; ♀, 24mm; of antennæ, ♂, 8mm; ♀, 10mm; of pronotum, ♂, 4mm; ♀, 5.4mm; of tegmina, ♂, 21.25mm; ♀, 27mm; of hind tibiæ, ♂, 9.25mm; ♀, 12.2mm.

1 ♂, Santa Cruz Island, No. 853, June, Dr. O. Loew. I have other specimens (♂, ♀) collected by Dr. Edw. Palmer, at San Diego, Southern California, in July.

[This species should not be confounded with a hitherto undescribed species from Tighes Station and Julian, Southern California, collected by Dr. Palmer, which I have marked in my collection as *Trimerotropis Juliana*. This latter species has the transverse bands of the wings formed of a rather faint fuliginous shade in the cells, than which the veins are scarcely darker; the contrast of colors upon the tegmina is greater, and the large dark spots are, if anything, broader next the costa, and certainly as distinct there as anywhere; the inner margin of the inner bar is nearly lost in the flecking of the base, and the spots of the apex of the tegmina are wholly or almost wholly confined to the upper and lower margins. The hind tibiæ have also a distinct, dark, basal annulus, and, finally, the median carina of the anterior lobe of the pronotum is not so elevated. In other respects, the two species can scarcely be distinguished; and one of the San Diego specimens of *T. pseudofasciata* approaches *T. Juliana* in having the cells in the banded area of the wings almost wholly fuliginous; but the veins, on the other hand, are so conspicuously darker than the fuliginous membrane that the resemblance is not so great as it otherwise would be; and, in other respects, the specimen conforms to the type of *T. pseudofasciata*. The two species agree in size.]

ANCONIA, (ἄγχω), *nov. gen.*

Head rather small, unusually smooth; space between the eyes above equal to twice the extreme width of the basal joint of the antennæ; fastigium nearly flat, a little transversely sulcate between the middle of the eyes, the lateral carinæ somewhat elevated but blunt, bent slightly inward and less elevated beyond the eyes, continuous with the outer margins of the flat frontal costa; the latter is as broad above as the basal joint of the antennæ, expands a little just above the ocellus, below which it contracts (in the ♀ to nearly half its greatest width), and remains of the same width nearly to the clypeus; in this contracted portion, it is sulcate; lateral foveolæ flat; lateral ocelli very large; eyes large, ovate, very prominent; antennæ moderately short,

inconspicuously enlarged on apical third. Pronotum expanding much, and almost uniformly toward the hinder extremity, the two lobes about equal, the anterior subcylindrical, the posterior nearly flat, with rather prominent but perfectly blunt lateral carinæ, the median carina scarcely visible on the posterior lobe, obsolete on the anterior lobe; anterior border minutely notched in the middle; posterior border obtusely angled, the angle rounded; deflected lobes almost longer than broad; mesosternal and metasternal lobes equidistant in both sexes. Tegmina very long and straight, with slight costal shoulder, the intercalary vein traversing nearly the middle of its area, the axillary uniting at its tip with the anal vein in the basal half of the wing. Hind femora very slender, but scarcely extending beyond the tip of the abdomen; none of the carinæ elevated.

This genus has the general aspect of *Trimerotropis*, but differs from it in nearly all its structural features. It has not a few points of resemblance to *Hadrotettix*, but can hardly be placed near that genus.

46. *Anconia integra*, nov. sp.—Apparently greenish yellow in life; apical half of antennæ faintly infuscated; head and most of anterior lobe of pronotum smooth, the posterior lobe profusely punctulate. Tegmina rather uniformly flecked with small, obscure, sometimes very obscure, fuscous spots; wings hyaline; the costal margin with a pallid stigma near the middle of the apical half of the wing, some of the veins near the apex infuscated. Hind femora pallid or hoary externally, sometimes with faint pre-median and post-median dusky bands, the edges of the geniculations testaceous; hind tibiæ pale yellow, the apical half of the spines reddish changing to black. Length of body, ♂, 19^{mm}; ♀, 32^{mm}; of antennæ, ♂, 8^{mm}; ♀, 10^{mm}; of pronotum, ♂, 4^{mm}; ♀, 6.5^{mm}; of tegmina, ♂, 22^{mm}; ♀, 32^{mm}; of hind tibiæ, ♂, 10.5^{mm}; ♀, 16^{mm}.

1 ♂, 1 ♀, Mojave Desert, Southern California, No. 829, Dr. O. Loew.

47. *Acrolophitus hirtipes* (Say) Thom.—1 pupa, Southern Colorado, June 11–20, Lieut. W. L. Carpenter.

48. *Brachystola magna* (Gir.) Scudd.—7 ♂, 6 ♀, Northern New Mexico, August to September, Lieut. W. L. Carpenter; plains of Northern New Mexico, eastern slope, October 14–31, Lieut. W. L. Carpenter.

49. *Tettix acadicus* (*Tettigidea acadica* Scudd.).—1 ♂, 1 ♀, 1 immature, Northern New Mexico, August to September, Lieut. W. L. Carpenter. This species has only been known hitherto by a single specimen from the Lake of the Woods, British America. By some oversight, it was placed by me in *Tettigidea*.

MANTIDES.

50. *Stagmomantis*, sp.—A single pupa of some species of this genus was brought from Colorado River, California; it was taken July 20, by W. Sommers, No. 868.

ENUMERATION AND INDEX OF SPECIES.

APPENDIX H 10.

NEW SPECIES OF COLEOPTERA, COLLECTED BY THE EXPEDITIONS FOR GEOGRAPHICAL SURVEYS WEST OF ONE HUNDREDTH MERIDIAN, IN CHARGE OF LIEUT. GEO. M. WHEELER, UNITED STATES ENGINEERS, BY JOHN L. LECONTE, M. D.

CREMASTOCHILUS, Knoch.

1. *E. Wheeleri.*—Brownish black, not shining; head feebly punctured, much dilated in front, broadly truncate; side angles rounded. Prothorax subquadrate, a little wider behind, sinuate on the sides; front angles acute, incurved, and densely hairy on the inner side; hind angles rounded, expanded posteriorly; middle third of disk depressed, covered with large, shallow punctures; lateral thirds separated by a shallow impression, more distinct near the base and tip, very sparsely punctured, rather shining and quite smooth behind the middle. Elytra with large, shallow, elongate punctures as usual; humeri shining; mesothoracic epimera not visible from above in consequence of the posterior expansion of the hind angles of the prothorax. Tibiæ compressed; front pair with two approximate teeth; middle pair with two distant teeth besides the apical one; hind pair with a small acute denticle about the middle; tarsi compressed, hind pair two-thirds as long as the tibiæ. Beneath feebly punctured, pubescent with brown hair; mentum deeply concave, subtriangular, bisinuate behind, with the side angles produced and rounded; hind margin feebly notched at the middle. Length, 10.6^{mm} = 0.42 inch.

Northern New Mexico, Lieut. W. L. Carpenter. In the division of the disk of the prothorax into three parts, this species seems to be related to *C. saucius*. The dividing groove is, however, not well defined, and in other respects there is no resemblance. The form of the mentum is quite peculiar, and in a group where specific differences are of less magnitude would warrant the establishment of a separate genus.

PLECTRODES, Horn.

2. *P. Carpenteri.*—Brown, clothed above with dense, short, pale pubescence, with long hairs intermixed on the head and prothorax. Clypeus slightly broader in front; side angles broadly rounded; front margin subsinuate, narrowly reflexed. Prothorax with the sides much less rounded than in *P. pubescens*. Body beneath and legs clothed as in that species with very long hair; abdomen densely covered with very short, appressed pubescence. Length, 21^{mm} = 0.83 inch. ♀ clypeus less prolonged, with the margin more widely reflexed; club of antennæ small; last joint of maxillary palpi smaller than in ♂, and tarsi a little shorter.

Los Angeles and Mohave Desert. Differs from *P. pubescens*, Horn (Trans. Am. Ent. Soc., I, 167), only by the characters mentioned above. It is a curious fact that all the specimens of that species collected at Visalia, Cal., were males. The females, as is the case with *Polyphylla variolosa*, probably remained on the ground or at the entrance of their subterranean dwellings.

ATHOUS, Esch.

3. *A. cribatus.*—Slender, dark brown, sparsely pubescent; front deeply, triangularly impressed; margin strongly reflexed. Prothorax one-third longer than wide; sides nearly straight; hind angles not prolonged, nor carinate, slightly divergent; surface coarsely and deeply punctured. Elytra finely striate; interspaces flat, punctured. Antennæ with the second joint one-third as long as the third, which is triangular, and as long as the fourth. Tarsi long, slender, not lobed beneath. Length, 7.5–10^{mm} = 0.30–0.40 inch.

Southern Colorado and Northern New Mexico; found also on Taos Peak. According to the synoptic table (Candèze, Elat., iii, 421), this species would be placed next to *A. reflexus*, from which it is abundantly distinct by the smaller size and coarsely punctured prothorax.

4. *A. simplex.*—Slender, brown, sparsely pubescent; head densely, coarsely punctured; front deeply impressed; margin narrowly reflexed. Prothorax longer than wide; sides rounded; hind angles not prolonged, reflexed, not carinate; disk shining, sparsely punctured. Elytra finely striate; interspaces flat, punctured. Antennæ with the third joint one-half longer than the second, narrower and shorter than the third. Tarsi long, slender, not lobed. Length, 7.5–11^{mm} = 0.30–0.43 inch.

Colorado, Mr. B. D. Smith.

ASAPHES, Curley.

5. *A. soccifer.*—Slender, brown, sparsely pubescent; front deeply concave; head strongly punctured. Prothorax more than one-third longer than wide, less strongly punctured than the head; sides nearly straight; margin reflexed; hind angles acute,

prolonged, divergent, finely carinate near the side margin. Elytra finely striate; interspaces flat, punctulate; antennæ strongly serrate; second joint small; third triangular, equal to the fourth. Length, 14 mm = 0.55 inch.

Northern New Mexico. This species resembles in appearance *Corymbites pyrrhos*, but the hind angles of the prothorax are less prolonged, and the antennæ are more strongly serrate. It also resembles *Athous cucullatus*, but differs by the antennæ being more strongly serrate, and also by the front being not reflexed. It is an intermediate between these two species of different genera, though differing from both by the broader antennæ. The tarsal lobes are less developed than in the other species of *Asaphes*, and the anterior margin of the front is somewhat above the labrum, and rather well defined.

A careful examination of this species convinces me that the genera *Corymbites*, *Asaphes*, and *Athous*, as at present comprehended, should be united; an opinion which has been already expressed by my learned friend, Dr. Candèze (Elat., iii, 208), and which he would have announced more definitely had he not attached too great importance to the authority of Kirby, Germar, Lacordaire, and myself.

COLLOPS, Er.

6. *C. hirtellus*.—Above clothed with long, erect, black hair; head and prothorax greenish black, shining, feebly punctulate. Elytra blue, deeply but finely punctured. Epistoma, margin of labrum and first joint of antennæ testaceous: abdomen testaceous, with large, lateral, black spots; legs nearly black. Length, 4.5 , = 0.45 inch.

Northern New Mexico, found on Taos Peak, 13,000 feet elevation.

7. *C. reflexus*.—Above clothed with long, erect, black hair; head and prothorax scarcely punctulate, black; side margin of the latter strongly reflexed, especially toward the base, brownish. Elytra very densely and finely punctured, without luster. Antennæ testaceous, in the ♀ spotted with brown. Legs black; abdomen pale testaceous, with the last segment black; epistoma and labrum testaceous. Length, 5 mm = 0.20 inch.

Northern New Mexico.

MALACHIUS, Fabr.

8. *M. montanus*.—Elongate, greenish black, not polished, slightly pruinose, with very short pubescence; head with a deep impression; epistoma white. Prothorax wider than long, rounded on the sides, which are feebly reflexed toward the base, narrowly bordered on the sides with red. Elytra finely scabrous; apical margin pale beneath, and legs black. Length, 3.5 mm = 0.14 inch.

Northern New Mexico. The antennæ are pectinate in the ♂, and the elytra are not appendiculate. This species is related to *M. Ulkei*, Horn, but differs by the prothorax being only narrowly bordered with red, and by the apical margin of the elytra being pale.

PODABRUS, Fischer.

5. *P. lateralis*.—Elongate, slender, black, very finely pubescent; head feebly punctulate, opaque, alutaceous; in front of the eyes testaceous. Prothorax nearly as long as wide, subquadrate, rounded on the sides in front of the middle; front angles rounded; hind angles small, prominent; disk punctulate, longitudinally concave, with two large convexities, also broadly impressed transversely in front, with the apical margin reflexed; dorsal line finely impressed; sides narrowly margined and pale. Elytra finely scabrous, opaque. Beneath, legs and antennæ black. Length, 7mm = 0.28 inch.

Colorado and Northern New Mexico; found on Mount Taos, at 13,000 feet elevation. The antennæ of the ♂ are rather longer and stouter, and the second joint comparatively smaller, than in the ♀.

Belongs with *P. lævicollis*, *puncticollis*, &c., but is quite distinct by the characters given above. The claws are appendiculate.

HYDNOCERA, Newman.

9. *H. hamata*.—Black bronze, with a green reflexion on the head and prothorax; thinly clothed with erect white hairs. Elytra sparsely, not very strongly, punctured, with a large, common, pale, spot diverging from the suture, and broadly hooked behind the middle. Antennæ, palpi, and legs testaceous. Length 3.4mm = 0.13 inch.

One specimen, Northern New Mexico. Very closely allied to *H. pallipennis*, but the head and prothorax are less opaque, less alutaceous, and more distinctly rugose; the elytral markings are also different; the arrangement of color might be equally well

described by saying that the elytra are pale, with a side margin, and the apical fourth black; the black extends narrowly along the suture nearly to the middle, and from the side margin proceeds an oblique stripe ending behind the middle, midway between the lateral edge and the suture; the tips of the elytra are separately rounded and feebly serrate.

NOTOXUS, Fabr.

10. *N. digitatus.*—Elongate, brownish testaceous, clothed with fine pubescence and with many intermixed fine, long hairs. Head finely punctured, obliquely narrowed behind the eyes, truncate at base; hind angles rounded. Prothorax globose, finely punctulate; horn in front deeply concave, with but five large rounded teeth, one apical and two on each side; hind part of horn suddenly elevated; summit narrow, acutely margined, and with the edge not serrate. Elytra very finely punctulate, paler, with two irregular dusky bands connected by a longitudinal dusky line; tip subtruncate; sutural angle rounded. Length, 3mm = 0.12 inch.

One specimen, Southern Colorado. This species is allied to *N. serratus*, but the horn is quite different by the small number of teeth, and the form of body is less elongate.

I have several other new species of this genus from the interior regions of the continent, and they would well repay the labor of preparing a revision and synoptic table.

MACROBASIS, Lec.

11. *M. murina*, Lec., Proc. Acad. Nat. Sc. Phil., 1853, p. 344 (*Cantharis*).—Several specimens of both sexes were found in Northern New Mexico; the males are quite similar to the two collected by me at Lake Superior, and which were considered by Dr. Horn as a variety of *M. unicolor*. The females, however, differ from that species by the second joint of the antennæ being but little shorter than the first, and nearly equal to the next two united. I am not prepared to say that this is a difference of specific value, for there are in several parts of the *Meloide* family indications of a flexibility of structure which we are not yet prepared to account for.

Catalogue of the Coleoptera collected by the explorations during 1875.

The collections were made in two parts of the country surveyed, which are so distant as to have but little zoological relation. I have therefore thought it more useful to prepare two separate lists; the first containing those species collected in California as far east as the Mohave Desert and as far north as Santa Barbara. Small collections from Santa Cruz Island are included, and do not exhibit anything peculiar or previously unknown. The second list contains species found in Southern Colorado and Northern New Mexico, mostly from the eastern foot-hills of the Rocky Mountains. Fourteen specimens were collected by Lieut. W. L. Carpenter on Taos Mountain, at an elevation of 13,000 feet. Three of them are new, but are found at lower elevations, and do not specially indicate arctic or subarctic affinities. These fourteen species are marked with an * in the following list.

I.—*Californian Coleoptera.*

B, Santa Barbara. Cr., Santa Cruz Island. M, Mohave Desert and Colorado River.

Omophron dentatum	Cr	Dermestes talpinus	Cr
Calosoma semiloeve	B	vulpinus	B
cancellatum	B	Helichus productus	M
Lebia cyanipennis	M	Tropisternus californicus	Cr, M
Calathus ruficollis	M	Hydrocharis glaucus	Cr
ruficollis, var	Cr, B	Philhydrus normatus	Tejon
Platynus brunneo-marginatus	Cr, B	perplexus	Tejon
maculicollis	M	Necropharus guttula	B
Pterostichus, n. sp.? (race of vicinus?)	B	Silpha ramosa	B, M
vicinus	B	lapponica	B
laetulus	Cr	Quedius explanatus	S. Cal
Amara californica	Cr	Thinopinus pictus	S. Cal
Chlaenius tricolor	M	Philonthus canecens	B
Anisodactylus consobrinus	Cr	Sinodendron rugosum	B
Bembidium Mannerheimii	Cr, B	Atænius stercorator	M
Hippodamia vittigera	B, Cr, M	Plectrodes Carpenteri	M
ambigua	M	Cyclocephala hirta	M
convergens		longula	M
Coccinella californica		Dichelonycha pusilla	B
Psyllobora taedata	M	Anorus piceus	M

I.—*Californian Coleoptera*—Continued.

Photinus (Ellychnia) facula	M	Noserus plicatus	B
(Pyropyga) californica	M	Cryptoglossa verrucosa	M
Telephorus tibialis	M	Coniontis viatica	Cr
Carpophilus pallipennis	Cr	subpubescens	Cr. B.
Ditemnus obtusus	M	Eleodes armata	Angeles & M
Pristoscelis sordidus	M	acuticauda	B
Clerus quadrisignatus	M	dentipes	B
Polycaon Stoutii	Cr	producta	B
ovicollis	Cr	cordata	B
Amphicerus punctipennis	M	Cratidus osculans	Cr
Prionus californicus	B	Amphidora littoralis	M
Stenaspis solitaria	M	Eulabis pubescens	M
Xylotrechus insignis	B	obscura	B
Lema trilineata	M	Blapstinus pulverulentus	B
Chrysochus cebaltinus		Copidita quadrimaculata	B
Diabrotica trivittata		Cantharis vulnerata	S. Cal.
soror		Thricobaris mucorea	M
Phloeodes diabolicus	Cr, B	Scyphophorus yuccæ	M

II.—*Coleoptera of Southern Colorado and Northern New Mexico, collected in* 1875, *by Lieut. W. L. Carpenter, Ninth Infantry.*

Cicindela longilabris.
pulchra.
splendida (*race* amœna).
purpurea (*race* Audubonii).
Cimmarona (*var.* greenish bronze).
12-guttata (*race* guttifera).
repanda.
cinctipennis.
punctulata.
Notiophilus semistriatus.
Calosoma scrutator.
calidum.
obsoletum.
Carabus serratus.
baccivorus (*race* Agassizii).
Cychrus elevatus.
Pasimachus elongatus.
obsoletus.
duplicatus *var.*
Dyschirius sphæricollis.
Loxopeza atriceps.
Lebia vividis.
Cymindis abstrusa *Lec.*
brevipennis *Zimm.*
cribricollis *Lec.*
Calathus dubius.
Platynus cupripennis.
placidus.
octocolus (Taos Mountain).
Evarthrus substriatus.
constrictus.
Pterostichus protractus.
Luczotii.
(Poecilus) lucublandus.
Amara (Lirus) laticollis.
(Bradytus) latior *Kirby.*
hyperborea *Lec.*
libera *Lec.*
laevistriata *Putsg.*
oregona *Lec.*
Amara polita.
chalcea (Taos Mountain).
interstitialis.
terrestris.
obesa.
Chlaenius laticollis.
sericeus.
Agonoderus pallipes.
Harpalus amputatus.
retractus.
herbivagus.
oblitus.
basillaris.
Cratacanthus dubius.
Bembidium tetraglyptum.
Hydroporus striatellus.
Laccophilus decipiens.
Colymbetes binotatus.
Agabus obliteratus.
Gyrinus, not determined.
Tropisternus nimbatus.
Silpha lapponica.
ramosa.
truncata.
Creophilus villosus.
Dermestes marmoratus.
Trox scutellaris.
Sonoræ.
Alhodius occidentalis.
(Taos Mountain).
Hoplia laticollis.
Diplotaxis brevicollis.
Dermestes nubilus.
Erotylus Boisduvalii.
Carpophilus pallipennis.
Hippodamia quinquesignata.
Lecontei.
convergens (Taos Mountain).
parenthesis (Taos Mountain).
sinuata.
Coccinella trifasciata.
9-notata.
5-notata.
prolongata.
bipunctata (*var.* humeralis).
Exochomus marginipennis (*var.* æthiops).
Brachiacantha ursina.
Epilachua corrupta.
Hister abbreviatus.
Saprinus lugens.
plenus.

II.—*Coleoptera of Southern Colorado and Northern New Mexico, &c*—Continued.

Dorcus mazana.
Onthophagus Hecate.
Phanæus carnifex.
Bolbocerus Lazarus.
Diplotaxis Haydeni.
Serica sericea.
Dichelongcha Backii.
sulcata.
Tostegoptera lanceolata.
Lachnosterna fusca.
and another species.
Listrochelus, probably new.
Polyphylla 10-lineata.
Euphoria Kernii.
Cremastochilus Wheeleri, *n. sp.*
Trichius affinis.
Aphonus pyriformis.
Chalcophora angulicollis.
Buprestis maculiventris, *race* rusticorum.
Langii.
Melanophila miranda.
longipes.
Melanophila Drummondi.
gentilis.
Anthaxia inornata.
Chrysobothris triennaria.
Acmaeodera pulchella (*race* variegata).
Anelastes Druryi.
Alaus lusciosus = gorgops *Lec.*
Drasterius dorsalis.
Melanotus incertus.
Asaphes coracinus.
soccifer, *n. sp.*
Corymbites, *n. sp.* (broken).
Athous cribratus, *n. sp.* (Taos Mountain).
Photinus (Ellychina) lacustris.
(Pyropyga) thoracicus = flavicollis *Lec.*
nigricans.
Chauliognathus basalis.
Podabrus lateralis, *n. sp.* (Taos Mountain).
Collops bipunctatus.
reflexus, *n. sp.*
hirtellus, *n. sp.* (Taos Mountain).
Trophimus æneipennis.
Malachius montanus.
Pristoscelis texanus.
Listrus analis.
Dolichosoma nigricornis.
Trichodes ornatus.
Clerus cordifer.
moestus.
Hydnocera hamata, *n. sn.*
Amphicerus bicaudatus.
Prionus Californicus.
Homaesthesis emarginatus.
Batyle ignicollis.
discoideus.
Leptura propinqua.
convexa (Taos Mountain).
canadensis (*race* cribripennis).
Pachyta liturata.
Acmaeops pratensis.
Typocerus brunnicornis.
Monilema annulatum.
Monohammus clamator.
Dectes spinosus.
Tetraopes canescens.
Bruchus prosopis.
amicus (Arizona, in seeds of Circidium floridium).
Orsodacna childreni.
Coscinoptera vittigera.
Cryptocephalus confluens.
notatus.
Chrysomela multiguttata.
exclamationis.
auripennis (Taos Mountain)
Gonioctena pallida (Taos Mountain).
Plagiodera lapponica.
scripta.
Colaspis tristis.
Phyllobrotica decorata.
Adimonia externa.
Trirhabda convergens.
Monoxia debilis.
Disonycha triangularis.
punctigera.
Disonycha glabrata.
Graptodera obliterata.
Orchestris albionica (Taos Mountain).
Odontota Walshii.
Epitragus canaliculatus.
Asida opaca.
polita.
convexicollis.
rimata.
Coniontis ovalis.
Eleodes obscura.
tricostata.
obsoleta.
extricata.
hispilabris.
nigrina.
pimelioides.
Blapstinus pratensis.
Corphyra Lewisii.
Notoxus digitatus, *n. sp.*
Anaspis nigra (Taos Mountain).
Mordella scutellaris.
Meloe sublaevis.
Megetra vittata.
Cantharis vividana.
sphaericollis.
Macrobasis immaculata.
tricolor.
murina.
Epicauta maculata.
ferruginea.
Nemognatha apicalis.
Thecestermus humeralis.
Ophryastes vittatus.
sulcirostris.
Pontaria rugicollis *Horn.*
Diamimus subaeneus *Horn.*
Epicaerus imbricatus.
Thacolepis inornata *Horn.*
Centrocleous angularis.
Cleonaspis lutulentus.
Stephanocleonus plumbeus, *Lec.*
Cleonus vittatus.
Dorytomus mucidus.
Laemosaccus plagiatus.
Balaninus nasicus.
Baris striatus.
Cossonus subareatus.

APPENDIX H 11.

REPORT ON THE ALPINE INSECT FAUNA OF COLORADO AND NEW MEXICO, SEASON OF 1875, BY LIEUT. W. L. CARPENTER, NINTH INFANTRY.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., May 1, 1876.

SIR: I have the honor to submit a report on the alpine insect fauna of Colorado and New Mexico. A separate entomological collection was made during the season of 1875, at high altitudes, which has proved of interest in its relation to geographical distribution and in the production of many rare and new species.

It is to be hoped that future collectors will not overlook this important field for zoological research, but will endeavor to increase our limited knowledge of the insects of this region.

Very respectfully, your obedient servant,

W. L. CARPENTER,
First Lieutenant Ninth Infantry.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in Charge.

The mountain-ranges of the world produce a fauna of remarkable interest in its bearing upon the discussion of geographical distribution and the existence of varietal forms which have resulted from the great climatic changes through which the globe has passed.

In the elucidation of geological epochs, we find that even the lowest forms of life have a history which, could we but trace back through the dim ages which have intervened since the dawn of life, would throw a flood of light upon many subjects at present conjectural. When it is found that certain insects occur uniformly in the mountains of Asia, Europe, and America, at great elevations, and in British America at high latitudes, the geological significance of this fact becomes apparent; and the mind reverts to a period when the steady encroachment of a vast field of ice caused the extinction of delicate species and compelled the survivors to change their habitat for lofty mountains, which had become islands in a sea of ice. Here, amid new conditions of temperature and a modified flora, a few hardy species were perpetuated, which have preserved their alpine characteristics to the present time.

Thus we find certain insects on Mount Washington, New Hampshire, which are lost sight of as we journey westward through the great expanse of valley and plain to the foot of the Rocky Mountains; as we ascend them and approach the verge of the alpine flora, these same species re-appear with wonderful regularity, establishing the perfect identity of the insect-fauna of our mountains.

With the return of a genial climate, during the Champlain period, the ice receded to the north, releasing the fauna from its imprisoned state, and stimulating all life to again spread over the continent. The valleys and plains were once more filled with species which found the warmth of the new climate congenial to their tastes; these, spreading over the land and mingling with other forms which followed the retrogression of the ice from its southern limit, produced the fauna as it now exists. Other species, to which a boreal climate had become agreeable, finding the increasing temperature of the valleys distasteful, migrated to the northward in the path of the ice, which was slowly uncovering the country, until they found a suitable habitat in the arctic regions. The few species which remained upon the mountain-peaks lingered about their old haunts until the climate which we now have had become established and their retreat accordingly prevented. They are thus imprisoned in the mountains, contented with a modified climate so nearly resembling that voluntarily chosen by their relatives which have colonized the barren ground of the far north. Consequently we find these species dwelling in an extremely isolated range, although having a geographical distribution only dependent upon a requisite elevation above the level of the sea, or an equivalent high latitude and consequent congenial climate.

The alpine insect fauna of America should then be regarded as but a fragment of that which survived the geological changes which occurred at the close of the Tertiary and beginning of the Quaternary epochs. Although the mountain genera and species are nearly all represented in the arctic fauna by the same species or their analogues, yet the number inhabiting the latter region is greatly in excess of the former, as would naturally be supposed in view of the general migration of the alpine fauna, set free by the northward movement of an isothermal zone. With such similarity existing between them, the study of both faunæ becomes necessary in instituting any comparison between individuals of the same species for the purpose of determining varietal differ-

ences which are the natural outgrowth of the modifications of food and climate produced during ages of separation. The primary causes of differentiation, however, appear to be of a geological rather than meteorological nature; the climatic causes operating as a factor, which subsequently appeared as a necessary sequence of the termination of the Glacial period. This interesting fauna obviously possesses characteristics which at once attract attention and induce study in determining the great causes which have operated to produce such a remarkable distribution of life.

The observations of Dr. A. S. Packard, jr., on the geographical distribution of the moths of Colorado, have established the fact of the existence of a law of increase in the length of certain peripheral parts for western species. Professor S. F. Baird and Mr. J. A. Allen have shown that the same law of variation obtains in regard to the birds of North America. Dr. Packard states that the moths of the Pacific coast are generally larger than those of the Rocky Mountains, and almost invariably larger than the same species from New England and Labrador; and he considers the difference in growth to be due to the more genial climate and greater rain-fall of the western coast. While a difference of temperature and relative humidity exercise an influence over the growth and coloration of insects of sufficient importance to be accepted as a factor affecting their development, this is probably also due in some degree to the prevalence of high winds, which have operated to produce greater development of the wings as a natural result of greater habitual exertion in combating them; and perhaps also to the acquisition of nomadic habits rendered necessary in a comparatively barren region, where vegetation is not as exuberant as in more civilized localities which have been under cultivation for a long time. The swarming grasshopper, *Caloptenus spretus*, which by its periodic migrations, extending over 20° of latitude, proves so destructive to our agricultural interests, singularly confirms this law. This insect, having been accustomed to sustain long continued flights, has consequently developed more powerful wings than the same species which occurs in the Eastern States, in no respects differing from the western insect except in its habits of more local residence and shorter wings.

As regards variation of color, I believe that species from a cold climate, or where there is an unusual absence of sunshine, will be characterized by the predominance of somber-hued types, or will present a bleached appearance when compared with specimens from a warmer climate. In the arctic regions, the short summers seem poorly adapted to the development of vivid colors, and we accordingly find few of the beetles known to occur there which are remarkable for bright colors; the same fact is noticeable in those obtained from the western mountains above the timber-line. A notable exception to this rule, however, is *Carabus vietinghovii*, Adams, from Hudson Bay; a northern insect, which may well vie with tropical species in brilliancy of color. This insect may be regarded as an example of the effect of a short period of almost constant sunshine, such as prevails during the summer in this part of the circumpolar regions. More complete data regarding variation in color should be collated before the facts can be regarded as establishing any conclusive law of melanism affecting species inhabiting separate zoological zones.

Although I have not had an opportunity to institute extensive comparisons between collections from different mountain-regions, observations made in the West during several seasons have convinced me that, in general, the animal kingdom existing at great elevations is as dwarfish as the vegetable kingdom. This is especially apparent in the *Coleoptera*, *Hemiptera*, *Orthoptera*, *Neuroptera*, and *Arachnida*, the types of which are usually represented by the smaller species. But this does not appear to be the case with the *Lepidoptera*, *Hymenoptera*, and *Diptera*, which furnish large-sized forms, especially prominent among which are the *Papilionidæ*, *Argynnides*, *Apidæ*, and *Tabanidæ*.

The *Coleoptera* show a remarkably uniform distribution over Colorado, Oregon, and the circumpolar regions. So apparent is this, that a species obtained at a great elevation from Colorado may be looked for with almost certainty in these other localities.

Further research will probably verify this distribution in other orders. The collection of spiders exhibits a striking resemblance to those found in the barren grounds of the far north, by Captain Back, R. N., whose collections contain four genera; all of which occur above timber-line, and have the same habits of living in the ground and rocky crevices, incumbent in regions of stunted and scant vegetation. Among the grasshoppers obtained by Captain Back, we find *Acridium sulphureum*, Pal. de Beauvoix. (*Tomonotus sulphureus*, Fabr.), which is found in the mountains of Colorado; and although it has not yet been obtained above timber-line, it may be accepted as a true resident of that desolate region. From the *Fauna Boreali-Americana*, we have *Locusta leucostoma*, Kirby (*Caloptenus bivittatus*, Uhler), found by Sir John Richardson, latitude 65° north, and which is also a western species. Among other mountain *Orthoptera*, the genus *Pezotettix* should be regarded as a typical alpine form; two species having been found at an elevation of 13,000 feet.

The *Hymenoptera* were among the insects earliest observed above timber-line. Frémont records the presence of bumblebees amidst snow and ice on the summit of the

Rocky Mountains during his overland journey. They are also known to be the first insects to appear in the early spring in the arctic regions.

The *Apidæ* are well represented in this collection, and have their prototypes reproduced in the arctic regions with remarkable fidelity.

Anthophora bomboides, Kirby, and *Bombus borealis*, Kirby, from latitude 65° north, occur also in the mountains of Colorado and New Mexico as alpine species. *Allantus basilaris*, Say, found above timber-line, is a species widely distributed and *à priori* ought to be found in the arctic regions by future collectors.

A few circumpolar species of butterflies which occur also in Colorado and New Mexico, appear to be among the very rarest of the western species; such are *Vanessa antiopa*, Linn; *Cynthia huntera*, Fabr. (*Pyrameis huntera*, Drury); and *Hipparchia nephele*, Kirby. Subsequent collections will probably disclose their existence in greater abundance along a zone following the Rocky Mountains northward, and bending eastward through the Lake Superior region to Hudson Bay and Canada, and branching westward to Oregon and Northwest British America.

In a region of sparse vegetation, the *Hemiptera* would necessarily be few in numbers; the insects of this order found in the arctic regions are represented in this collection only by the genus *Miris*, although *Lygæus reclivatus* is a species to be looked for in British America, as it is one of those singular forms apparently endowed with a remarkable vitality, which has enabled it to survive great climatic changes, and consequently to acquire extensive geographical distribution.

Among the most interesting of the butterflies is *Chionobas semidea*, Say, which occurs in the Alps, Rocky Mountains, and on Mount Washington, N. H. Its presence in the mountains of Asia may be considered as extremely probable. The writer was informed by Dr. S. H. Scudder that in the Swiss Alps it appeared to be a sluggish insect, unable to sustain long flights, and consequently easily taken. In our western mountains, it has a strong, rapid flight, and is one of our most wary species, although quite common at an elevation of 14,000 feet.

Colias meadii, Edw., and *Argynnis freya*, Esper, are truly alpine butterflies; the former has its analogue, *C. hecla*, in the Arctic regions.

The southern Rocky Mountain chain appears to support a greater abundance of some orders of insects than the northern. A season's collecting above timber-line in Northern Colorado only produced five species of butterflies, while the mountains of New Mexico yielded sixteen species. The ratio of luxuriance, however, in the case of some other orders is largely in favor of the northern mountains, a result seemingly incongruous, but which undoubtedly bears directly upon the biology of each order of insects. Of all orders, the *Lepidoptera* is the one which most delights in a warm climate and bright sunshine, and any deviation from such a habitat should be regarded as an involuntary change, rendered obligatory by the slow substitution of a cold climate during ages of progress in their development. The temperature of the climate of the mountains of New Mexico is considerably warmer than that of the same elevations in Colorado; the alpine flora consequently extends into higher regions in New Mexico, making a suitable habitat for the *Lepidoptera*, *Hemiptera*, and *Diptera*, three of the most delicate orders of insects.

The *Coleoptera*, *Hymenoptera*, *Orthoptera*, and *Arachnida*, being more hardy, accordingly predominate in more northern regions.

A table is here presented, embodying the results observed.

	More abundant above timber-line in—	
Hymenoptera	Colorado.	
Lepidoptera		New Mexico.
Diptera		New Mexico.
Hemiptera		New Mexico.
Coleoptera	Colorado.	
Orthoptera	Colorado.	
Arachnida	Colorado.	
Myriapoda	Colorado.	

It is but quite recently that thorough alpine collections have been made, and our knowledge of this fauna is consequently not very extensive, being at present restricted to the mountains of Colorado and New Mexico. The northern Rocky Mountain chain offers a new field for the further investigation of this subject, which will undoubtedly produce many other species to be added to the catalogue, and establish still more conclusively the relationship existing between the alpine and the arctic faunæ.

This report is based upon collections made by the writer during the season of 1875,

while employed with the Colorado section of this Survey. The results here presented should be regarded as but an imperfect outline of the entire fauna. Other collections ought to be made before sufficient material will have been secured to enable the naturalist to discriminate between actual residence and some few species which may owe their presence to storms or atmospheric currents, and thus would not properly belong to this *fauna*. But with each comparison of collections the constant recurrence of certain species will designate those which should be regarded as conterminous. It is a difficult matter to determine a vertical limit for alpine species, because a few forms occurring in the foot-hills sometimes encroach upon the verge of the alpine flora.

The altitude of 12,000 feet above the level of the sea, which is about 300 feet above timber-line, has been therefore selected as the elevation best calculated to yield a collection characteristically boreal; and all species below enumerated were accordingly taken at a considerable altitude above timber-line.

The following is a conspectus of the alpine insect fauna of Colorado and New Mexico:

HYMENOPTERA.

|| Bombus borealis.
Bombus flavifrons.
Bombus rufocinctus.
Bombus ternarius, Say.
Allantus basilaris, Say.
Cryptus robustus, Cres.
Odynerus tigris, Sauss.
Lyda Carpenterii, Cress.
Ammophila robusta, Cress.

LEPIDOPTERA.

Papilio Asterias, Fabr.
Papilio Zolicaon, Boisd.
¶ Parnassius Smintheus, Doub. 3 varieties.
Colias Keewaydin, Edw.
† Chionobas Semidea, Harris.
Chrysophanus Sivius, Edw.
Thanaos brizo, Boisd.
Thanaos persius, Scudd.
Hesperia Centamea, Rambur.
Colias meadii, Edw.
Argynnis Carpenterii, Edw., new species.
Argynnis helena, Edw.
Melitæa nubegina, Beh.
Phyciodes Carlotta, Reak.
Grapta Latyrus, Edw.
Euptychia Henshawi, Edw., new species.
Erebia Tyndarus, Edw.
Pieris occidentalis, Reak.
|| Argynnis freya, Esper.
†‡ Arctia Quenselii, Paykull.
‡ Agrotis islandica, Staub.
Anarta melanopa, Thunb.
Plusia Hochenwarthi.

DIPTERA.

Syrphus obliquus, Say.
Musca erythrocephala, Meigs.
Bibio ———.
Tachinidæ ———.
Anthomyidæ ———.
Tipula ———.
Pachyrrhina ———.
Melanostoma ———.
Sarcophagidæ ———.

COLEOPTERA.

* Carabus taedatus, Fabr.
* ‡ † Nebria Sahlbergii, Fisch.
* ¶ Platynus octocolus, Mann.
Amara chalcea.
* Amara terrestris, Lec.
† ‡ Amara obtusa, Lec.
* Bembidium tetraglyptum, Mann.
Silpha ramosa, Say.
Hippodamia convergens.
Hippodamia parenthesis.
Aphodius coloradensis.
¶ Coccinella transversogutta, Fald.
Athous cribratus, Lec., new species.
Podabrus lateralis, Lec., new species.
¶ † ‡ Podabrus lævicollis, Kirby.
Collops cribosus, Lec.
Collops angustatus, Lec.
Collops hirtellus, Lec., new species.
* ¶ † || Adoxus vitis, Linn.
** Leptura convexa, Lec.
¶ Gonioctena pallida, Linn.
Chrysomela auripennis, Say.
Chrysomela dissimilis, Say.
Trirhabda convergens, Lec.
Orchestris albionica, Lec.
¶ Anaspis nigra, Hald.
* Alophus alternatus, Say.
Stereopalpus guttatus, Lec.
* ¶ Dendroctonus obesus, Mann.

HEMIPTERA.

Thyanta perditos, Fab., ♂ var.
Lygaeus reclivatus, Say.
Miris instabilis, Uhler.
Coriscus ferus, Linn.
Trapezonotus nebulosus, Fallen.
Agalliastes punctulatus, Uhler.
Geocorris bullatus, Say., var.
Orectoderus amocoens, Uhler.
Lygaeus circumcinctus, Stal.
|| Aradus americanus, Fab. (affinus).

* Found also in Alaska.
† Found also on Mount Washington, N. H.
‡ Found also in Labrador.
¶ Found also in British America.
|| Found also in Arctic regions.
** Found also in Oregon.

ORTHOPTERA.

Caloptenus spretus, Uhl.
Pezotettix stupefacta, Scudd., new species.
Anabrus coloradus, Thom.
Pezotettix Marshallii, Thos.
Platyphyma montana, Thos.
Gomphocerus Carpenterii, Thos.

ARANEINA.

Attoidæ, 1 species.
Drassoidæ, 5 species.
Theridoidæ, 1 species.
Thomisoidæ, 2 species.
Lycosoidæ, 14 species.

MOLLUSCA.

Isthania simplex, Gould.
Lonites nitidus, Müll.

MYRIOPODA.

Lithobinus Americanus, Newport.

APPENDIX H. 12.

NOTES ON THE MAMMALS TAKEN AND OBSERVED IN CALIFORNIA IN 1875 BY H. W. HENSHAW.

FELIDÆ.

1. *Felis concolor*, L.—Cougar; American Panther.

This formidable Cat appears to have disappeared almost entirely from the lower and more thickly settled districts, and is found now only in the heavily-timbered regions of the deep mountains. In winter only, and when the deep snows have rendered precarious its usual methods of obtaining food, does it descend from its mountain fastnesses and make known its presence by its depredations on the farmer and ranchman.

CANIDÆ.

2. *Canis latrans*, Say.—Coyote; Prairie Wolf.

The persistent efforts of sheep-raisers and farmers have resulted in the almost complete extermination of this animal from many parts of California. Comparatively few were met with by our parties during the past season. As its name indicates, it is a rather exclusive inhabitant of the plains and lowlands. The mountains are not infrequently visited by them in summer; they there finding, perhaps, the seclusion they court during the season of reproduction, as well as a greater abundance of food.

3. *Urocyon cinereo-argentatus*, (Screb.) Coues.—Gray Fox.

A fine female of this species was shot by Dr. Rothrock near Walker's Basin. This was the only specimen secured, though they were seen with sufficient frequency to warrant the statement that they are numerous in Southern California. As with the Coyotes, strychnine administered by the sheep-herders has reduced their numbers very materially. They inhabit the wild mountainous districts, which are well timbered; woodland being more essential to the mode of life of this fox than to most others of the family.

No.	Sex.	Locality.	Date.	Collector.
719	♀ ad.	Walker's Basin, Cal	Aug. 27, 1875	Dr. J. T. Rothrock.

4. *Urocyon cinereo-argentatus*, (Screb.) Coues, var. *littoralis*, Baird.—Island Fox.

This, the smallest of our North American Foxes, was brought to the notice of naturalists through specimens obtained by Lieutenant Trowbridge on the island of San Miguel, off the coast of California. Though noticing the marked similarity in its external appearance when compared with the common Gray Fox (*Vulpes virginianus* of most authors), Professor Baird yet treated the present animal as a distinct species, though in his article in vol. VIII, Pacific Railroad Report, he expresses the doubt as

to whether it is not merely a local race of that animal. An excellent opportunity was had during the past season of examining numerous specimens of this little Fox in the field, and, since returning, of making direct comparison of the skins of the two animals, as well as comparing the crania. The result shows an extremely close relationship, and, as remarked by Professor Baird, size alone appears to be the only external character of much importance in the discrimination between the two animals, the Island Fox being in round terms but about one-half the size of its congener. In color the discrepancies are quite unimportant, and are almost, if not quite, within the usual range of individual variation. Perhaps the Island Fox may be of a generally darker tone of coloration throughout. Specimens, however, taken in June, while they show a deeper tint of rufous, lack the decided glossy black mixture of the back and tail shown on a Gray Fox shot in August in the Sierra Nevadas, this being replaced by a blackish-brown color. This may be a purely seasonal difference.

A comparison of crania of the two animals shows no distinctive peculiarities of moment, those noted by Professor Baird appearing to be merely individual.

The islands in the Santa Barbara Channel, where alone, so far as is now known, this animal is found, have long been separated from the mainland, with which geological evidence shows they were formerly connected. Supposing them, at the time of their isolation from the mainland, to have been inhabited by the Gray Fox, which, as is well known, extends from the east quite to the Pacific coast, still retaining its typical form, we may readily assume that in the long interval that has since elapsed, pent up within a very circumscribed area and subject to greater or less changes in the conditions of life and climate, the animal has deteriorated in size to what we now find it, without having suffered other notable differentiation. Principally to a difference in food may, perhaps, be ascribed the diminution in size.

Taking into consideration the complete isolation of the two forms in question, and the fact that no perfect intergradation of size can be shown to connect them, we might perhaps be justified in according full specific rank to this Fox, and this while fully admitting the extreme probability of it having originally sprung from the allied species. I have thought best here, however, to consider it merely as a varietal form of the ordinary Gray Fox.

It was only upon the island of Santa Cruz that I had the opportunity of seeing this animal, though I was informed by good authority that all the group contained them in greater or less numbers. Upon all portions of Santa Cruz* they are abundant, and in certain parts they exist in almost incredible numbers. On the west, the high broken ridges descend in a somewhat gradual slope to the shore, and this portion is clothed with a scanty growth of cactus (prickly pear). This seemed to be a favorite resort of the Foxes, or else the large number seen here was due to the lack of undergrowth, and their consequent inability to find good hiding-places. In passing over the terrace-like plateaus, where the cactus-plants were tolerably thick, I had no difficulty in starting up one of these animals every few moments. No fewer than fifteen were seen in a two hours' walk. Of timidity they showed scarcely a trace, and fear of man had certainly never been inherited by the individuals I saw. The scanty shade afforded by the cacti was here their only protection from the hot sun, and snugly rolled up underneath these plants, I usually found them taking their noonday naps. Arousing themselves to the situation when my footsteps within a few feet of their retreat awoke them, they would quietly walk out a few steps. The most timid moved off at an easy trot, now and then throwing a glance backward, as if somewhat doubtful of our intentions. From the character of the droppings I concluded that their food, at least at this the summer season, must be largely insectivorous, and such proved to be the case. The beaches, too, doubtless supply more or less of their subsistence, though the tracks found upon these in the morning did not indicate that they resorted to them in very great numbers.

On one occasion I had an excellent opportunity of watching one of these little animals as he was busily engaged hunting his supper. His search, as long as I followed him, which he permitted me to do at a short distance, was limited to insects, especially grasshoppers, which he found on the open plain among the scanty herbage and under small stones. These, after a preliminary sniff told him that game was beneath, he readily turned over with his long snout.

Notwithstanding the fact that the island is crowded with sheep, I could not learn that any depredations had been traced to the Foxes. On the contrary, they appeared to be considered by the herders as perfectly harmless, although it seems most probable that the young lambs must suffer from their attacks. They prove a determined enemy to the Gulls, Cormorants, Guillemots, and other sea-birds that congregate on the islands for purposes of reproduction, so that these are forced from the main island, and compelled to deposit their eggs upon the little inaccessible islets contiguous. Quite a number of their nests which had been rifled of their contents came under my observation.

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* This island is distant from the mainland about 16 miles, being the nearest. It is about 30 miles in length, with perhaps an average width of 5 miles.

In preparing the skins of some half dozen of these Foxes I noticed a curious fact, which may be worth mention. In each instance the interior surface of the hide was perforated by a fewer or greater number of the cactuo spines. Of one, apparently an old patriarch, the hide was fairly coated with these spines, which, having penetrated, had worked through and had become disposed along the horizontal surface of the skin. So thick were they that a point of a knife-blade could hardly have been applied to the skin without touching one or more. Many had become soft and flexible with age, while those more recently introduced were hard and stiff,

They probably whelp quite early in the summer. I saw, however, but one litter of young. These, about six weeks old, I found June 3, close to the mouth of a subterranean burrow, and, coming suddenly upon them, I had no difficulty in catching one of them in my hands. The little fellow made no attempt to bite, but immediately began to howl most lustily, when the mother came trotting out from some retreat hard by, and, approaching to within a few feet, looked up into my face with a most earnest, pleading expression, which effectually deprived me of all desire to do injury either to her or her offspring. After a moment's silent pleading, she slowly walked off, keeping an eye on my every motion, and, having withdrawn a short distance, awaited till my departure gave her a chance to regain her progeny.

Measurements—fresh specimens.

	No. 3.	No. 4.	No. 5.
Tip of nose to canthus of eye	1.75	1.75	1.65
Tip of nose to ear	2.75	2.75	1.55
Tip of nose to occiput	2.00	1.86	2.00
Tip of nose to tail	14.25	13.65	13.25
Tail, from root to end of vertebra	10.50	9.00	10.50
Tail, from root to end of hairs	12.75	11.25	12.62
Arm, from elbow to end of claws	2.75	2.75	2.50
Leg, from knee-joint to end of claws	4.75	4.25	4.00

No.	Locality.	Date.	Collector.
1	Santa Cruz Island, Cal.	June 1	H. W. Henshaw.
2	......do	June 1	Do.
3	......do	June 1	Do.
4	......do	June 2	Do.
5	......do	June 2	Do.
720	......do	June 3	Do.
721	......do	June 3	Do.
994	......do	June 1	Do. (alcoholic.)

5. *Vulpes vulgaris pensylvanicus*, (Bodd.) Coues.—American Red Fox.

From sheep-herders I learned of the existence in the region about Mount Whitney of a Fox which, without hesitation, I refer to this species with the greater certainty, inasmuch as I had an opportunity of examining a young one which had been captured at the base of Mount Whitney. The animals were said to be quite numerous, and to live by preference along the borders of the extensive mountain-meadows.

MUSTELIDÆ.

6. *Mephitis mephitica*, Baird.—Common Skunk.

The Skunk appears to be as common in Southern California as anywhere in the East. It is most often found along the borders of the streams. One that I stumbled upon had arranged a rather neat nest in the tops of some dead rushes, a foot or so from the water, in which it was lying curled up fast asleep.

7. *Mephitis bicolor*, Gray.—Little-striped Skunk.

Though known to be a resident of California, none of this diminutive species were noted by our parties. A beautiful specimen was presented me by Captain Forney, of the Coast Survey, he having obtained it from the island of San Miguel, the outermost of the Santa Barbara group.

8. *Taxidea americana*, (Bodd.) Bd.—American Badger.

Throughout Southern California, the Badger is a very common animal, ranging upward to a height of at least 8,000 feet.

It was noticed that their burrows were frequently made with direct reference to the abundance of the "Gopher Squirrel" (*Spermophile harrisii*), and these no doubt constitute no small proportion of their food, a fact which might well be borne in mind by the farmers, to whom these squirrels are almost a deplorable scourge.

No.	Sex.	Locality.	Date.	Collector.
718	♀ ad.	Walker's Basin, Cal.	Aug. 28, 1875	Francis Klett.

URSIDÆ.

9. *Ursus horribilis*, Ord.—Grizzly Bear.

Perhaps few animals have suffered more from persistent and relentless warfare waged by man than this formidable Bear. To the sheep-owners especially, whose immense flocks under the care of one or two men are driven far into the heart of the mountain wilderness to pass the summer months, are these animals special objects of dread. Accordingly every means in their power are used for their extermination. A supply of strychnine is part of the outfit of every shepherd, and by means of this the number of Bears is each year diminished, till in many sections where formerly they were very abundant they have entirely disappeared. This is particularly the case with the Grizzly, whose nature seems to be far more savage, and who courts the secrecy of the deep wilderness far more assiduously than his congeners, the various varieties of the Black Bear.

Accordingly, in many thinly-settled regions, where the latter is still by no means uncommon, the Grizzly has entirely disappeared, having been killed out or forced to withdraw to more inaccessible sections.

In some sections, however, as in certain portions of the mountains near Fort Tejon, the Grizzlies are quite numerous, sufficiently so as to make deer-hunting on the mountain ridges, where the chaparral grows in almost impenetrable clumps, a matter of no little danger.

It is an indisputable fact that the temper of the Grizzly of the Sierra Nevadas and of the same species of the Rocky Mountains is very different. The latter seems to be an animal to be dreaded but little, if any, more than the Black, Brown, or Cinnamon Bears of the same region, and rarely has it been known to assume the initiative in a contest with man.

Very different is it in the Sierras, where stories of unprovoked attacks by Grizzlies are frequent, and not few are the lives lost in such encounters.

10. *Ursus americanus*, Pall.—Black Bear.

The various types of this Bear, known as the Black, Brown, and Cinnamon varieties are all found in California, and are more or less numerous.

The approach of winter sends down from the mountains many of these animals, which often congregate in some locality which proves favorable for a supply of food, and where earlier they do not appear at all. Thus, in the hills near Caliente their broad tracks were everywhere visible in the oak-groves, where they had descended in the night from their lurking places in the deep cañons and the dense chaparral thickets, to feast upon the rich harvest of acorns.

OVIDÆ.

11. *Ovis montana*, Cuv.—Rocky Mountain Sheep.

A small band of these animals was seen upon the summit of Mount Pinos, in the Coast range, and another near the top of Mount Whitney. Their tracks were frequently observed by the parties who ascended the lofty summits of the Sierras, though they are apparently less numerous in California than in many parts of the Rocky Mountain region.

12. *Antilocapra americana*, Ord.—Prong-horned Antelope.

The dry plains in various portions of Southern California are tolerably well stocked with Antelopes, bands of which may occasionally be seen close to the lesser-traveled roads. Their extreme wariness, as well as the desert nature of much of the country inhabited by them, serves to protect and prevent their extermination.

CERVIDÆ.

13. *Cervus canadensis*, Erx.—American Elk.

The Elk has almost entirely disappeared from Southern California, in some portions of which it existed in great numbers but a few years since. I was informed by relia-

ble authority that a few still remain, making their abode in the impenetrable tulle swamps that environ the Tulare and Kern Lakes.

14. *Cervus columbianus*, Rich.—Black-tailed Deer.

This is the prevailing Deer throughout the Coast range, as well as the Sierra Nevada, and is in many sections numerous, though we everywhere heard of their constantly-diminishing numbers.

The summer is passed among the high mountains, where the ridges clothed with chaparral form their retreat during the day, the bucks especially ascending to the bases of the highest peaks. At the beginning of cold weather, they gradually work down into the warm and sheltered valleys, there to pass the winter.*

Like the Bears they resort to the oak-groves to glean the crop of acorns, of which they are very fond.

TALPIDÆ.

15. *Scapanus townsendi*, Bach.—Oregon Mole.†

To this species is referred a mole taken at Santa Barbara.

Measurements.—Nose to root of tail, 5.00; tail to end of vertebra, 1.28; to end of hairs, 1.43; fore foot, 1.00; hind foot, 0.80; breadth of palm, 0.60.

No.	Locality.	Date.	Collector.
992	Santa Barbara, Cal	July —, 1875	H. W. Henshaw.

16. *Hesperomys* (*Vesperimus*) *americanus*, (Kerr) Coues.—White-footed Mouse.

This, the common species of the interior region, was seen in many localities throughout Southern California, and specimens secured.

It may be mentioned as of interest that these little animals appeared to figure largely as an item of fare of the large Brook-trout (*Salmo* ——*?*), which abounds in the north fork of the Kern River. Scarcely one of the trout was taken that one or more of these Mice was not found in its stomach, while from one fish of unusually large size no fewer than five were taken. The trout secure them at night as they run about the margin of the pools.

17. *Arvicola* (*Myonomes*) *riparius*, Ord.

A widely-distributed species, and one common in Southern California. Lives principally beneath rotten logs.

18. *Ochetidon longicauda*, (Bd.) Coues.

This little Mouse appears to be confined to California, no specimens having been taken, so far as I am aware, elsewhere. It there replaces the allied species *O. humilis*, the Harvest Mouse of the region east of the Rocky Mountains.

Measurements.—Specimen No. 207: Nose to occiput, 0.81; to ear, 0.67; to eye, 0.33; to tail, 2.03; tail vertebræ, 2.70; with hairs, 2.75; fore foot, 0.25; hind foot, 0.63; ear above notch, 0.50.

No.	Sex.	Locality.	Date.	Collector.
207	♂ ad.	Santa Barbara, Cal	July 6, 1875	H. W. Henshaw.
1300	♀ ad.	Mescal, Cal	May 1, 1875	Lieut. Eric Bergland.

19. *Dipodomys phillipsii ordi*, (Woodh.) Coues.—Kangaroo Rat.

A single specimen of this Rat was secured by Mr. Hasson near Los Angeles.

No.	Locality.	Date.	Collector.
993	Southern California	July —, 1875	J. A. Hasson.

* Quite a number of Bats were secured during the season, but have not yet been identified.

† For the identification of this and others, especially the species of *Muridæ*, I am indebted to Dr. Coues.

20. *Cricetodipus parvus*, Bd.—Least Kangaroo Mouse.

A single specimen from near Fort Tejon proves to be of this extremely rare and interesting species. This, the fourth specimen known, serves to substantiate more fully the specific distinction made between it and the single other member of the genus, *C. flavus*.

Measurements.—Nose to occiput, 0.90; to ear, 0.77; to eye, 1.47; to tail; 2.05; tail vertebræ, 2.50; with hairs, 2.75; fore foot, 0.25; hind foot, 0.65; ear above notch, 0.28.

GEOMYIDÆ.

21. *Thomomys* (*Talpoides*(*umbrinus*, (Rich.) Coues.—Black-faced Gopher.

This Gopher was found to be very abundant in many localities of Southern California, and its dispersion over the country would appear to be very general. Its habits are not very well known, chiefly from the fact that most of its existence is passed under ground. It moves about from place to place through long burrows made just beneath the surface of the ground; tunnels being driven outward every few feet to admit of foraging on the surface for all sorts of small seeds. The little heaps of earth with which it always closes the mouths of its burrows are noticeable in all directions where the animal is found, and sufficiently attest its activity during the night hours; for, I believe, its habits are chiefly nocturnal, though they may often be noticed at work in the early morning and late afternoon. In the fall, when perhaps the approach of winter hurries them in their efforts for laying up the needed supplies, their labor is continued during the sunny hours of the day.

Their sense of hearing is wonderfully keen, and the chief reliance to warn them of danger. When perfectly silent, a person may remain within a few feet of the mouth of their burrows and watch their motions at will.

No.	Sex.	Locality.	Date.	Collector.
188	♀	Santa Barbara, Cal	July 5, 1875	H. W. Henshaw.
329	—	Fort Tejon, Cal	Aug. 8, 1875	Do.
345	—	......do	Aug. 9, 1875	Do.
243	—	Santa Barbara, Cal	July —, 1875	Do.
995	—	......do	July —, 1875	Do.

SCIURIDÆ.—SQUIRRELS.

22. *Sciurus leporinus*, Aud. and Bach.—Californian Gray Squirrel.

This large and beautiful species was found to be extremely abundant in certain portions of the Coast range, and also in the Sierras. Its distribution over California appears to be very general, In summer I found them living almost exclusively among the pines, where they found an abundance of the seeds. The ground under the trees was often covered with the husks of these and with the cones half eaten. In the fall they resort very much to the oak-groves, whence they glean a rich harvest of acorns.

The chestnut patches at the base of the ears appear to be wanting in summer, as of quite a number of individuals taken in the worn summer pelage none possessed this conspicuous mark.

No.	Sex.	Locality.	Date.	Collector.
265	♀	Tejon Mountains, Cal	Aug. 3, 1875	H. W. Henshaw.
281	♂	......do	Aug. 3, 1875	Do.
602	♂	Mountains near Kernville, Cal	Oct. 25, 1875	Do.

23. *Sciurus douglassii*, Bach.—Oregon Red Squirrel.

This Squirrel was found to be extremely numerous in the pineries of the Sierras, extending nearly, if not quite, up to the pine limit. It has many of the ways of the eastern Red Squirrel, with which its habits correspond most closely, but its notes are very different. These are so sweet and pleasing as to almost entitle them to be ranked as a song, and indeed their voices were mistaken for those of birds by more than one of our party.

No.	Sex.	Locality.	Date.	Collector.
446	♀	Near Mount Whitney, Cal	Sept. 6, 1875	H. W. Henshaw.
447	♀	......do	Sept. 6, 1875	Do.
458	♂	......do	Sept. 10, 1875	Do.
459	♂	......do	Sept. 10, 1875	Do.
742	......	......do	Sept. 10, 1875	Do.

24. *Tamias quadrivittatus*, (Say) Rich.—Four-striped Squirrel.

Distributed throughout California, where confined to the mountains. Abundant.

No.	Sex.	Locality.	Date.	Collector.
447	♂	Near Mount Whitney, Cal	Sept. 6, 1875	H. W. Henshaw.
448	♂	......do	Sept. 6, 1875	Do.
449	♀	......do	Sept. 10, 1875	Do.
449*A*	♀	......do	Sept. 10, 1875	Do.
460	♂	......do	Sept. 10, 1875	Do.
721	♀	......do	Sept. 10, 1875	Do.

25. *Tamias lateralis*, (Say) Allen.—Rocky Mountain Chipmunk.

This is an other mountain species, which probably occurs throughout Southern California. It prefers rocky localities where underneath bowlders or fallen logs it excavates its habitations. Is rarely found other than in communities.

No.	Sex.	Locality.	Date.	Collector.
455	♂	Near Mount Whitney, Cal	Sept. 10, 1875	H. W. Henshaw.
456	♂	......do	Sept. 10, 1875	Do.
457	......	......do	Sept. 10, 1875	Do.

26. *Spermophilus harrisii*, Aud. and Bach.—Antelope Squirrel.

This little creature was noticed in several districts in Southern California. It lives in communities on the dry, sandy plains, where the herbage is of the scantiest kind. Its nature is shy and timid in the extreme, and so quick and agile are its motions that even when found some little distance from its hole it proves no easy task to shoot one. Usually their quick ears and roving eyes warn them of coming danger in time to secure an unimpeded retreat, and the glimpse of a white tail, which is held upright after the manner of an antelope, as its frightened owner disappears beneath the ground, is all one usually obtains.

No.	Sex.	Locality.	Date.	Collector.
632	♂	Valley of Kern River, Cal	Oct. 27, 1875	H. W. Henshaw.

27. *Spermophilus beecheyi*, Richardson.—California Ground Squirrel.

No animal is perhaps better known throughout California than this Squirrel, and insignificant as it may be thought from its small size, its numbers are so vast that it proves to be one of the greatest nuisances to the farmer, and in many sections renders successful agriculture all but impossible. They live together in large colonies, and in some portions of the State where their increase has been left unchecked, it seems, to one passing through, as if the country was one vast burrow, so rapidly do their colonies succeed one another. Once firmly established, the ireradication is a matter of extreme difficulty. It is rarely possible to completely destroy a large colony, and if a few pairs are left they soon multiply to such an extent as to make their ravages on corn-field or vegetable-patch seriously felt; in sections where their numbers are greatest, I was informed that not infrequently the loss by these little indefatigable thieves had reached one-half the corn-crop.

Their burrows are usually made in an uncultivated patch of ground, most often a pasture immediately adjoining cultivated ground, and their raids rarely extend more

than 200 yards from home. Their ravages begin as soon as the first green leaf of cereal or vegetable appears above the ground, and cease only when the last kernel of grain has been carried away.

With regard to their rate of increase I was informed by a farmer, though seven or eight was the usual number produced at a birth, he had in one instance on opening a female found no less than thirteen embryos. As they are known to produce two or more litters during the year, their excessive multiplication will thus not appear surprising. Poisoning by strychnine appears to be the only sure means for their suppression. This is neither easy nor always safe, since in exposing poisoned grain there is always danger of killing horses and cattle; and as the farmer and ranch succeed each other by turns, the extermination of these pests fails from lack of the necessary co-operation.

No.	Sex.	Locality.	Date.	Collector.
174	♀ jun	Santa Barbara, Cal	July 1, 1875	H. W. Henshaw.
175	♀ jun.	........do	July 1, 1875	Do.
223	♂ ad ..	........do	July 7, 1875	Do.
239	♀	........do	July 8, 1875	Do.
240	♀	........do	July 8, 1875	Do.
512	♀ ad ..	Near Mount Whitney, Cal	Sept. 29, 1875	Do.

LEPORIDÆ.

28. *Lepus callatus*, Wagl.—Jackass Rabbit.

Numerous throughout Southern California.

29. *Lepus trowbridgei*, Bd.—Trowbridge's Hare.

A single specimen of this little Hare was obtained at Santa Barbara, where, however, it was not uncommon; it was the only species seen in that locality.

30. *Lepus sylvaticus*, Bach., var. *arizonæ*, Allen.—Arizona Gray Rabbit.

The locality where was taken one single example of this Rabbit was Kernville. They were very numerous here, living principally in the crevices of the rocks. I am inclined to believe that this form is spread over much of the southern half of the State. Many, presumably of this variety, were shot for food.

No.	Sex.	Locality.	Date.	Collector.
631	♂	Kernville, Cal	Oct. 25, 1875	H. W. Henshaw.

Respectfully submitted.

H. W. HENSHAW.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in Charge.

APPENDIX H 13.

REPORT ON THE OPERATIONS OF A SPECIAL PARTY FOR MAKING ETHNOLOGICAL RESEARCHES IN THE VICINITY OF SANTA BARBARA, CAL., WITH AN HISTORICAL ACCOUNT OF THE REGION EXPLORED, BY DR. H. C. YARROW, ACTING ASSISTANT SURGEON, UNITED STATES ARMY.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., December 18, 1875.

SIR: I have the honor to submit herewith a report of the operations of a special party under my charge detailed by you for the purpose of making ethnological researches in the vicinity of Santa Barbara, Cal. The report, as will be found, is prefaced by a short historical account of the region explored, as given by Cabrillo, a Portuguese, who visited the coast of California in 1542.

Very respectfully,

H. C. YARROW,
A. A. Surg. U. S. Army, Surg. and Zool. to Expedition.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in Charge.

On the 27th day of June, 1542, Juan Rodriguez Cabrillo, a Portuguese navigator in the service of Spain, left the port of Navidad, New Spain, with two small vessels, the San Salvador and La Victoria, to explore the coast of California, which he sighted on the 2d of July. Proceeding along it, on the 7th of October he came in view of two islands some distance from the mainland, which he named after his vessels; these islands, lying in Santa Barbara Channel, southwest of San Pedro, and now known as San Clemente and Santa Catalina. On these islands, Cabrillo found many aborigines, who at first showed great fear of the Spaniards, but finally, becoming friendly, told him of numerous other Indians on the mainland. Resting here but two days, he set sail on the 9th. Shortly afterward, reaching a spacious bay and following its shore-line, he soon came upon a large village of Indians close to the sea-shore. Here his ships were visited by the savages in canoes, from the great number of which he called their town *Pueblo de las Canoas*. It would appear impossible to fix the exact site of this town, but circumstances point to the city of Santa Barbara as the locality. On the 13th, resuming his voyage, he passed near two large uninhabited islands, now known to be Santa Cruz and San Miguel, and anchored in front of an extremely fertile valley. Here he was visited by many natives coming to sell fish, who informed him that the whole coast was densely populated as far northward as Cabo de Galera, or Point Concepcion of the present day. Northwest from the Pueblo de las Canoas, he discovered two islands, which he named San Lucas, afterward known as San Bernardo, and which at the present day are supposed to be those of Santa Rosa and Santa Barbara. Point Concepcion was reached by this Portuguese navigator on November 1, after much suffering from cold, winds, and tempests. Anchoring near this place to obtain wood and water, he called the port *de las Sardinas*, from the abundance of fish thereabouts. Here were found many natives of most friendly disposition, one of whom, an old female, said to be the Queen of the Pueblos, came off to the captain's ship and remained two nights. Returning to the Island St. Lucas on account of bad weather, on the 3d of January Cabrillo died on the island called *la Posesion*, believed to be the present San Miguel. Of the manner of his death, and his notes in regard to the Indians he saw, we shall have occasion to speak hereafter. With this account of one of the earlier explorers of the region to be visited by ourselves, as a proper preliminary to a report of our own operations, we now proceed to give the latter in detail, first, however, briefly mentioning the circumstances which led to the exploration in question.

It is reported that some years ago the captain of one of the small schooners common to the Pacific coast returned from a visit to the island of San Nicholas, and stated having seen quantities of pots, stone implements, skulls, and divers sorts of ornaments on the surface of shell-heaps, which had been uncovered by storms, and exhibiting in proof of his assertions a number of these articles which he had brought with him, and which he distributed among his friends. It is reported that this captain again visited San Nicholas and its neighbor, Santa Catalina, and returned with a full schooner-load of relics, but this part of the tradition lacks confirmation.

Little attention was paid to this most valuable archæological discovery until 1872 and 1873, when Mr. W. G. W. Harford, of the United States Coast Survey, happened on the islands of San Miguel and Santa Rosa, lying to the northward and westward of the islands before mentioned. From these islands this gentleman procured a small but exceedingly valuable collection of interesting objects, which came into the hands of Mr. Wm. H. Dall, a most intelligent and enthusiastic collector, from which he deemed the locality of sufficient importance to visit it in person. This he did in the winter of 1873 and 1874. Mr. Dall visited San Miguel and Santa Catalina, but as his time was limited, no thorough examination was made of this mine of archæological wealth lying then temptingly open to view. He, however, procured many interesting specimens. During the same season, Mr. Paul Schumacher, well known for his investigations farther up the coast, discovered in the vicinity of San Luis Obispo and the Santa Maria River, deposits similar to those found on the islands. The results of these discoveries being communicated to the Smithsonian Institution, this establishment determined to make a thorough and exhaustive exploration of not only the mainland, but also of the islands; and, in the spring of 1875, Mr. Schumacher was named to conduct the work in behalf of the National Museum. By a fortunate coincidence, one of the parties of the Expedition for Explorations west of the One hundredth Meridian under the War Department, of which the writer was placed in charge, was about to visit the Pacific coast, and an arrangement was entered into whereby hearty co-operation and unity of effort were effected. Mr. Schumacher was to explore the islands, and the Exploring Expedition party the mainland along the coast from Santa Barbara north for a distance of 20 or 30 miles.

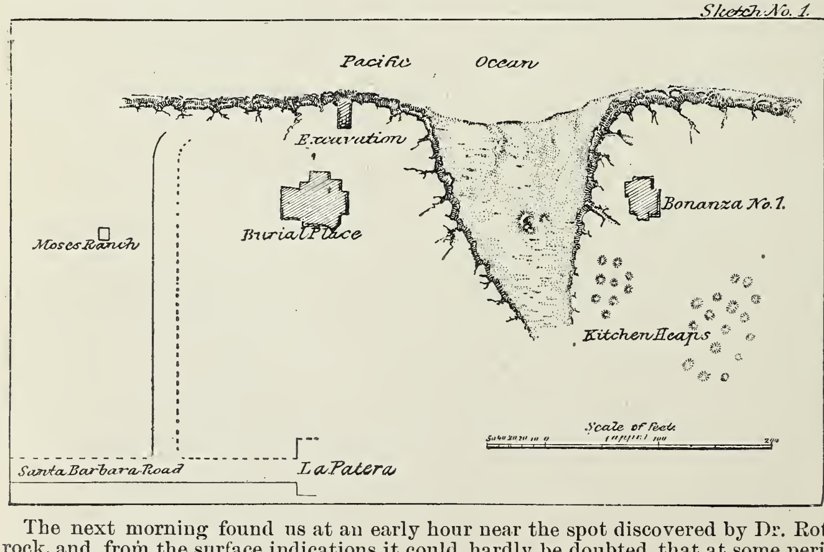
Leaving San Francisco June 4, after a pleasant sail of forty-eight hours, we arrived at Santa Barbara, the *Pueblo de las Canoas* of Cabrillo, and there found the other members of the party, consisting of Dr. J. T. Rothrock, botanist, and Mr. H. W. Henshaw, ornithologist, whom you had directed to assist in the enterprise. Arrangements were at once made to explore the neighborhood, and the day following that of our arrival we started, and under the guidance of the Rev. Stephen Bowers, whom we were in-

formed had already made some excavations in the section about to be visited, for the ranch of T. Wallace More, near the little village called La Patera, some eight miles from Santa Barbara. Arrived at a spot where our guide informed us he had found a few bones and arrow-heads, the work, digging a trench in a north and south direction on a cliff overlooking the sea and probably 80 feet above it, was at once commenced. There were no indications that this locality had been used as a burial-place, but after digging a few feet, and beyond some loose bones that had been reinterred by Mr. Bowers on the occasion of his first visit, we came to an entire skeleton *in situ*. It was lying on the right side, facing the west, with the lower limbs drawn up toward the chin. No ornaments or utensils were found, but a quantity of marine shells were near the cranium. Continuing the excavation deeper, two other skeletons were discovered in a similar position to the first, and near them a few broken arrow-heads. These were removed and the excavation extended downward and backward from the sea-cliff, the labor being rewarded by the finding of seven other skeletons. These latter, however, were huddled together and gave no evidence that care had been taken in the burial of the bodies to place them in any particular position. Near by were a few shell-beads and other ornaments, and an abalone shell (*Halietus splendens*) containing a red pigment. The bones were so friable as to crumble to pieces on exposure to the atmosphere, and on this account none could be secured. On excavating to a depth of 5 feet, a layer of marine shells was reached, under which was a firm stratum of yellow, sandy clay, beneath which, as our subsequent experience proved, burials were never made. After digging for several hours, and finding nothing further of special interest, the trench was refilled.

Moving around from place to place in the field, our attention was finally attracted to a depression in the center of it, some 200 yards from the sea-cliff, which on examination gave undoubted evidences of being a burial-place, ribs and vertebræ of whales being scattered about, and small inclosures found that had been made in the earth by setting up large flat stones on their sides. Digging into one of these inclosed areas, broken bones and some broken pestles and mortars were found, but nothing of special value. The excavation was continued to a depth of 3 feet only, which, as subsequently ascertained, was not sufficient. We left this locality for a time.

While engaged in the interesting search in question, Dr. Rothrock, who had strolled off some distance after botanical specimens, communicated to us that he had discovered, on the opposite side of a small *estero* to the northward, a locality which he believed to be a burial-place, founding his belief on the fact that he had seen a number of whales' ribs, placed so as to form arches over certain spots. As we well knew that the Santa Cruz Island burial-grounds were similarly marked, we anticipated a "good find," and, indeed, so richly were our anticipations rewarded that we named it the "*Big Bonanza*." The annexed diagram will give an idea of this place and the several other localities already mentioned.

Sketch No. 1.



The next morning found us at an early hour near the spot discovered by Dr. Rothrock, and from the surface indications it could hardly be doubted that at some period it must have been a burial-place of note. The surface of the ground, instead of presenting the appearance of mounds, or hillocks, was rather depressed in a semicircular form, and in various spots ribs and vertebræ of whales had been partially buried in the

ground, the ribs in some instances being placed together, as reported by Dr. Rothrock, in the form of arches. Selecting what appeared to be a favorable place, 20 feet from the edge of the cliff, fronting the *estero* shown in the map, a trench was commenced running due north and south. Two feet below the surface the first indications of burials were reached, quantities of broken bones being met with at every stroke of the spade, interspersed with pieces of whales' bones and decaying redwood. At a depth of 5 feet the first entire skeleton was found in position, and near it several others were subsequently uncovered; in all of them the head fronted northward, the face was downward, and the lower limbs were extended. Over the femur of one of the skeletons was a flat plate of steatite, a sort of soapstone, 12 or 14 inches square, with a hole in one end, which we called a "tortilla-stone," its probable use having been for cooking their cakes, or tortillas, the hole in the end serving to withdraw it from the fire when thoroughly heated. In rear of the skeleton, and to one side of the plate, was an olla, or jar, of steatite, broken, but containing some fine glass beads and human teeth, and behind this a stone pestle of symmetrical shape, about 3 feet in length, of a hard species of sandstone, and another plate of steatite, and two large ollas of over five gallons capacity, their mouths or apertures fronting north, and just above was a single cranium facing the cliff, face downward, and on top of it a single femur. Continuing the excavations toward the cliff, a small sandstone mortar was exhumed containing a mass of red paint, and in its immediate vicinity a large number of beads of glass and shell with ornaments made from the lamina of the abalone shell, which is common to this coast, being found in great abundance on the islands some 20 miles distant. Digging still farther, other skeletons were found in similar positions, but in many instances the lower limbs were flexed upon the body, while in a few cases the fingers of the right hand were in the mouth. One skeleton was that of a child, near which were found beads, ornaments, tortilla-stones, and two more ollas, one of which contained portions of the cranium of a child. This skeleton had apparently been wrapped in a kind of grass matting, as small portions were found attached to the bones and scattered near by. In the olla containing the head-bones of the child were a great number of small black seeds, smaller than mustard-seed, which were recognized by one of the laborers as a seed used by the present California Indians and natives in making demulcent drinks and eye-washes, the Spanish name being *chiya*.

A second trench, opened 40 feet from the first, yielded quite a number of excellent crania and other specimens, among which were fish-bones, crenated teeth, (of fossil shark possibly,) and a very large olla containing bones and covered on top with the epiphysis of a whale's vertebra. The following are the notes furnished by the gentleman in charge of the excavations at this point: First trench, 6 feet by 2, running north and south, trending to the westward. Indications of burials, whales' bones, and rocks set up vertically. Two and one-half feet below the surface found skeleton with face downward, head to the north. Three feet below surface reached a large flat stone, which being removed was found to cover ribs and shoulders of a female skeleton, head pointing north, body resting on left side. A small mortar was over the mouth, small sandstone mortar and pestle of fine workmanship near top of head. This locality proving rather unprolific, a second trench was commenced 40 feet below last, nearer cliff, and about of same size. Two feet below the surface to our great surprise a large steatite olla was discovered, which proved to contain the skeleton of an infant wrapped in matting. Unfortunately, upon exposure to the air, the bones crumbled away. Beneath the olla was a cranium, apex west, face north. Three feet below the surface were two skeletons in fair condition, with crania to the north. Our discoveries this day had developed so much of interest that it was not until darkness had overtaken us that we discontinued our work.

In order to give some idea of the amount of material recovered during the excavations, a record of each day's work follows:

June 10.—This morning began work shortly after sunrise at both trenches opened the day before, digging in a westerly direction in the first. In this, numbers of crania and bones were found in similar positions to the first met with, and also several fine ollas, tortilla-stones, mortars, and pestles. All these utensils were invariably in the immediate vicinity of the heads of the skeletons; in fact, in many instances the crania were covered by large mortars placed orifice down. In the second trench, the digging was in an easterly direction, and the first discovery that of a skeleton and a fragment of iron near the right hand, probably a knife or spear-head, which, archæologically speaking, was a source of great grief to us, our hope being that no remnants of Spanish civilization would be found in these graves. It could not be helped, however, although a great deal of pre-historic romance was at once destroyed. Near this skeleton was another, and by its side the first pipe met with, which was similar in appearance to a plain modern cigar-holder, and consisted of a tube of the stone called serpentine, 8 inches long, the diameter of the wider orifice being a little over an inch. At the smaller end was a mouth-piece formed from a piece of a bone of some large water-fowl, and cemented in place by asphaltum. How these pipes were used with any degree of comfort is impossible to surmise.

Continuing this excavation, the next discovery was a steatite olla containing a skull, differing in many respects from those found in the graves; if from one of the same tribe, it shows marked differentiation. Near the olla was a large sandstone mortar, over 2 feet in diameter, and behind it another olla containing more bones, and another pipe, 10½ inches in length, and near this latter article a smaller olla filled with red paint. It should have been mentioned that from this trench was procured a femur showing evidences of a fracture through the neck of the bone, which had become absorbed, the head uniting to the upper portion of the shaft between the greater and lesser trochanters. Further search revealed at the same depth a mortar, covered by the shoulder-blade of a whale, which also contained the skull of an infant covered with an abalone shell, while near by was paint, piece of iron, a nail, and various shell ornaments and beads. Near at hand, to the rear, were a broken mortar and pot underneath, which was a small olla, the whole covering the skull of a child; and a little deeper a skull resting upon a fine, large, pear-shaped steatite olla, the outside of reddish color. These remains appeared to have been inclosed in a sort of fence, as a plank and stakes of decayed redwood were near by. At the bottom of this trench, just above the firm clay, and under all the specimens just described, was a fine sandstone pestle 17½ inches in length.

June 11.—Continued in same trench, advancing in a northerly direction toward trench No. 1. At a depth of 4 feet were two skeletons, and near them was a square cake of red paint; alongside were two more skeletons, over one of which was a large mortar, mouth downward, and close by another similar utensil. Under this skeleton was an instrument of iron 14 inches in length, a long iron nail, and two pieces of redwood, much decayed. A little farther in was a small canoe carved from steatite. All the skeletons were face downward, heads to the north. In trench No. 1 the digging was continued in a southerly direction. The first object encountered was an enormous mortar, 27 inches in diameter, with its pestle near by. This article was on its side, the mouth toward the south; around it were no fewer than thirty crania, some in a fair state of preservation, and others very friable, broken, and worthless. Lying on top of this mortar, on further removal of the earth, was an almost entire skeleton, with fragments of long bones and of steatite pottery. As surmised by some of the party, the perfect skeleton was that of a chief, and the remains those of his slaves slain with him; which is at least a possible, if not a plausible, view of the case.

Experience by this time had taught us that nearly all the burial-places or spots had been carefully marked, since near the head of each skeleton were either bones of the whale or stakes of redwood.

Being obliged to leave for Los Angeles June 12, the work was continued by Mr. Bowers, who, up to June 25, secured the following articles from the two trenches in question, viz: 32 skulls, 24 large steatite ollas, 6 large mortars, 7 large pestles, 2 small serpentine cups, 7 tortilla-stones, 7 abalone shells, 3 iron knives, 4 stone arrow-heads, 1 iron ax of undoubted early Spanish manufacture, quantities of glass, shell beads, paint, shell ornaments, black seed of the character previously mentioned, 2 pipes, 2 soap-root brushes with asphaltum handles, and a copper pan 8 inches in diameter, which were found covering the top of a skull—the copper evidently having preserved a portion of the hair, which was quite black and silky, and not coarse, as is usually the case with Indians.

June 25.—The same excavation No. 2 was continued, and 3 crania were uncovered, also an olla containing the bones of a child, not far from which were 3 mortars and 2 ollas. Just above the stratum of clay the most interesting discovery was made of an entire skeleton, which had been buried in a redwood canoe, but which was so decayed that only a small portion could be preserved. Near the head of the canoe were a large olla and mortar, the mouths northward. On removing the skeleton, which was lying on its back, the bones fell to pieces. In the canoe, alongside of the skeleton, were 3 pestles, 2 pipes, an iron knife or dagger blade that had been wrapped in seal-skin or fur, and a stone implement of triangular form and about 6 inches in length, probably used as a file, or perhaps for boring out pipes.

June 26.—Trench No. 2 was abandoned and work resumed in No. 1, which yielded several crania in bad condition. Near a whalebone, standing on end, was an empty broken olla, and not far off a skeleton on its right side, legs drawn up, head facing west. On its right-hand side, near by, was a small highly-polished serpentine cup and a small mortar and pestle. After excavating awhile and finding nothing but broken bones, digging here was discontinued and an excavation commenced ten feet to the northward and near the edge of the cliff, but after going down 5 feet through kitchen refuse, ashes, bones, shells, it was filled up and work resumed at the same trench. Several hours' digging resulted in finding nothing, but finally the "lead" was once more struck. The first discovery was a skeleton, which, from the appearance of the pelvic bones, was that of a female, and near which were great quantities of beads, shell ornaments, and seeds. It was here we first encountered what at first sight appeared to be dried cloves, but which, on closer examination, proved to be ornaments of asphaltum, hollow in the center, and in some instances having at one end a small piece of dried grass or fiber,

by means of which doubtless they were fashioned into necklaces. Some abalone shells were also found, in close proximity to which were the bones of a child. Another mortar was discovered, containing some bones in bad condition.

June 27.—Being Sunday, operations were suspended until the next day.

June 28.—Work was resumed at trench, No. 1 but for 6 or 8 feet nothing was met with save isolated bones. Digging to the southward, however, a skeleton was found with top of head to the northward, the position of which was nearly face downward. On its removal and beneath it was a large mortar, cavity down, slightly tipped, and facing west. In another direction, to the eastward, was a large sandstone mortar facing north, and beneath it a skull in good condition, while near by was a small olla containing ornaments of shell, beads, seeds, and paint. Deeper down, still another small olla was revealed, filled with the black seeds, and near it a small pestle. A number of crania and bones were also found, but all in bad condition. One of them, however, was particularly interesting from the fact of two arrow-points, one of a porphyritic stone, the other of obsidian, being imbedded in the outer table of the skull. From the position of the arrows it was inferred that the wounds were received by the person while lying down. Digging in a northerly direction in this trench, 8 or 10 more skeletons, all huddled together, were exhumed, also 2 small pestles, 2 mortars, and some abalone shells containing ornaments. In one of the larger of these shells were the head-bones of a young child, and near it two polished serpentine dishes, containing some of the clove-like asphaltum before alluded to. A broken dish had been neatly mended with asphaltum and probably sinew, as drilled holes were found in both pieces. Not far from these cups was found a leather (?) pouch curiously ornamented on the outside with circles of shell-discs.

On June 29, finding that our labor was not as richly repaid as formerly, further excavation in this locality was delegated to Mr. Shoemaker, who, having discovered only 6 crania, and these in poor condition, after six hours' faithful labor, the "Big Bonanza" was abandoned, and in the meanwhile the writer was prospecting.

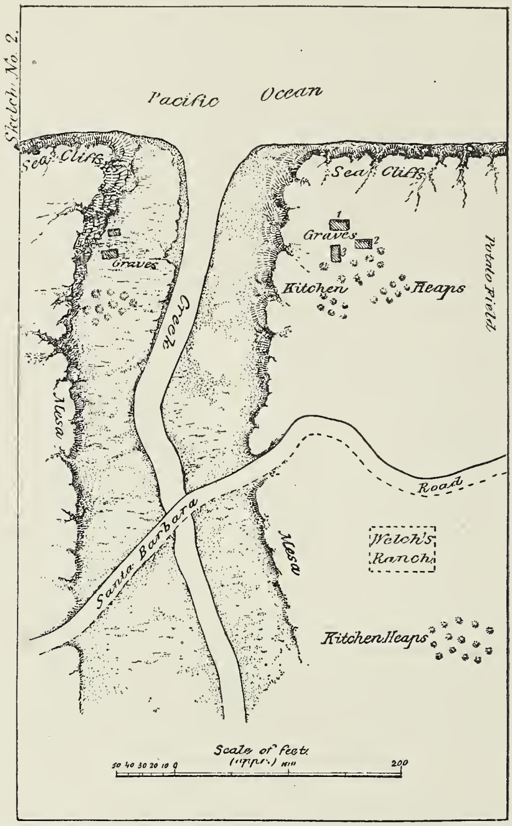
Crossing the estero, and reaching the ranch of T. Wallace More, esq., we visited the asphaltum mine, from which it is probable the Indians whose resting-places we had been so ruthlessly disturbing, procured their supplies of this, to them, most precious material, since it must have been extensively used in fastening on their arrow-heads or spear-points, and in mending and filling up cracks and holes in their canoes. Not far from this mine, the spot was reached which has been mentioned as that where burials were indicated by whalebones and flat stones, and it was determined to explore it next. Near it was a depression, in which appeared to have been either a threshing-floor or dancing-place, oval-shaped and 60 feet long by 30 or 40 wide. It had been beaten or trodden down so firmly that no vegetation could flourish thereon. In the afternoon, not far from camp, one of the party discovered some fragments of human bones which had been thrown out of a squirrel-burrow, which circumstance led us to search for relics. Opening a trench 300 yards to the westward from camp, at a depth of 3 feet, some broken bones were found and one skull; near the latter were a quantity of beads and a matted mass of fur, apparently of either the seal or sea-lion. After some hours' fruitless labor, digging in this locality was discontinued. This was the only instance in our experience where the burial of but one individual had taken place.

On the following day, one of the laboring party, assured of finding something to repay further labor in the "Big Bonanza," urgently suggested the same, whereupon excavating was again entered upon at that place; and, curiously enough, after a little digging, a remarkably fine knife of obsidian was discovered, nearly 10 inches in length; a bone implement, similar in appearance to a sword-blade; and two pipes, one of them ornamented. This ornamented pipe was the first of the kind we had met with, and we congratulated ourselves upon having yielded to the suggestion of the workman.

July 1.—Resolved to excavate in the locality last discovered, and an early start was made. This trench in T. Wallace More's ranch was commenced 200 yards from the sea-cliff. At a depth of 2 feet broken bones were uncovered, and at 4 feet entire skeletons, which in many instances had been inclosed with flat stones, forming a kind of coffin. Some mortars and pestles were here also met with, as well as pipes, arrow-heads, and another fine spear of flint, and one of iron. After four days' hard work, with no other results than those mentioned, this trench was abandoned. It is doubtless probable that many more articles might have been found here, but the time that would be consumed in securing a few small articles was demanded where results would most likely prove richer and more interesting.

From Dr. Taylor, of La Patera, a gentleman who for years had studied the ethnology and archæology of the Pacific coast, we learned of the probable existence of burial-places at a spot some 12 or 15 miles up the coast, known as Dos Pueblos, Dr. Taylor having there seen the remains of numerous kitchen-heaps, inferred that a large population once lived in that locality, and that their dead would be found not far distant. Accordingly Dr. Rothrock and the writer started on a prospecting tour, and after a couple of hours' ride came in sight of the Dos Pueblos ranch, occupied by Mr. Welch

and family. Making ourselves and object known to Mr. Welch, we received a welcome, and were invited to dig anywhere we might think proper. Mr. Welch showed us in his potato-patch numbers of broken bones that had been turned up by the plow; but being attracted by some whalebones partially imbedded in the earth of the sea-cliff near by, we immediately left the potato-patch, knowing from experience that where the whalebones are there also were graves. The position of these graves, as well as some others subsequently discovered, may be seen from the map. (See Sketch 2.)



The next day it was determined to move the entire party to this locality and excavate, which was done, the first trench being made at the point marked 1, near the brow of the cliff, where were whalebones and large, flat stones. At a depth of 4½ feet, great quantities of bones were found huddled together, but no skeletons in a particular posture. In some instances, stone receptacles, similar to the one already described, were encountered, but from their infrequency this burial feature was apparently not common. All the bones were in a very bad state, much worse than those about La Patera, and but few were preserved. Throughout the graves, but not placed in particular position, were several large mortars, large and small ollas, pipes, beads, and ornaments, besides bone awls. In locality No. 2, the same class of articles was brought to light, but in larger number.

In the narrative of Cabrillo, by Bartolome Ferrel, this locality is called Dos Pueblos, from the fact of there being two towns on opposite sides of the creek, which runs down from the Santa Inez Mountains. These towns were densely populated with a mild, inoffensive people. We were informed by Mrs. Welch that she had heard from an aged Indian woman that two separate tribes, speaking different dialects, lived on opposite sides of the creek, which constituted the boundary-line between them, and that the tribes were not permitted to cross this creek without first obtaining each other's consent.

Continuing our excavations in No. 2, a long, straight pipe and a small mortar having a handle, (the first of its kind,) and containing red paint, were found, and near the latter a pipe only partially bored out. On the opposite side of the creek a trench was

opened beneath a gigantic piece of whalebone, but several hours' work revealed nothing but broken bones, and it was abandoned and work resumed in Nos. 1, 2, and 3. During the 6th, 7th, 8th, 9th, and 10th, the excavating was continued, resulting in the discovery of mortars, ollas, pipes, &c., and curiously enough in No. 3 of no fewer than 30 skeletons which had been buried in sea-sand, and under which were 3 fine stone spear-heads and some fragments of iron. In No. 2 were several large ollas and mortars, and near the head of a skeleton, presumably that of a female, some china cups and saucers of very ancient shape. The time allotted to these explorations having now nearly expired, the remainder of our stay was devoted to filling up holes and packing the specimens. The specimens were roughly estimated as weighing from 10 to 15 tons.

Regarding the people of whom we have been speaking, and of whom no representative remains to tell of their history, but little could be learned; the crumbling bones and household gods we had so ruthlessly disturbed, were the only witnesses of the former existence of a once populous race; but beyond this they made no revelation, while careful examination of the entire literature of the Pacific coast proved fruitless in throwing light on these early generations. All the writers who speak of these aborigines, and it is but fair to state that few, if any, of them were possessed of original information on the subject, (having gathered their materials from Ferrel's narrative,) are of the opinion that they were friendly, peaceable, and inoffensive, which opinion is enforced by the absence in their graves of warlike implements to any extent. Cabrillo states that they were armed with bows, the arrows being pointed with flint heads, similar to those used by the Indians of New Spain; he also speaks of clubs, but mentions no other weapon. As to population, he states that on some of the islands there were no people, but that others were densely populated; the former we have not been able to identify. The Indians told him they had occasionally suffered from the attacks of warriors armed like the Spaniards, and from the fact that toward the middle of the eighteenth century the mission priests of Santa Barbara removed their savage parishioners from the islands to the mainland to escape the ravages of the Russians and their Kodiak allies, it is supposed that this warfare had been going on for a number of years. As to the extent of the population, we can form an idea only from the number of burials, at different points, and villages, the names of which have been handed down to us through Cabrillo. At a rough guess, our party must have exposed at their main trenches the remains of no fewer than 5,000 individuals, and, from what we have subsequently learned, there are hundreds of these burial-places along the coast.

With regard to the towns, the Indians informed Cabrillo that the whole coast was densely populated from the Pueblo de las Canoas to 12 leagues beyond the Cabo de Galera, (Point Concepcion,) and gave him the names of these towns. To the northward of their city was Xuco, Bis, Sopono, Alloc, Xabaagna, Xocotoc, Potoptuc, Nacbuc, Omlqueme, Misinagua, Misisopano, Elquis, Colve, Mugu, Xagna, Anacbuc, Partocac, Susuquiy, Omanmu, Gna, Asimu, Agnen, Casilic, Tucumu, Incpupu. These towns were in the immediate vicinity of the Pueblo de las Canoas. Near the Cabo de Galera, or Point Concepcion, as it is at present called, was the pueblo named by Cabrillo, "Pueblo de las Sardinas," in consequence of the great number of small fishes taken by the natives. In the neighborhood of this pueblo were the villages of Xixo, Cincacut, Cincut, Anacot, Maqumanoa, Paltated, Anacoat, Paltocac, Tocani, Opia, Opistopia, Nocos, Yutum, Iniman, Micoma, and Garomisopona. These towns or villages were ruled over by the aged queen to whom reference has been made, the capital and seat of government said to have been Cincut. Cabrillo also gives us the names of some of the towns on the islands; for instance, on one of them, which he states is 15 leagues long, probably San Miguel, Niquipos, Maxul, Xugua, Nitre, Macano, Nimitapol. On other islands not intelligibly specified were the towns of Ciquimuymu, Nicalque, Limu, Zaco, Nimollolli, Nichochi, Coycoy, Estoloco, Niquesesquelua, Poele, Pisqueno, Pualnacatup, Patiquin, Muoc, Patiquilia, Nimumu, Piliaquay, and Lilibique. He also mentions that on an island south of Isle de la Posesion was one called Nicalque; on this were three towns, Nicoche, Coycoy, Coloco. From this extended list it may be inferred that a large population once lived in the region explored.

With regard to the time that these people disappeared we can only conjecture. From the mission records it appears that in 1823, the total number of Indians in the vicinity of Santa Barbara was upward of 900, but this census embraced all Indians, and not alone those from the islands and sea-coast. In 1875, the year in which we write, not a soul can be found to give any information as to the ancient inhabitants of this part of the coast. There is a tradition that many years ago a Mr. Neidifer, while on a trip to the island of Santa Cruz, discovered there, much to his surprise, an aged hag, and that he removed her to Santa Barbara, but no one could understand her language, and after a short time she died; also that she was a young girl at the time the Indians were removed to the mainland, and returning from the boats to seek her infant, in the hurry and confusion of the embarkation she was left behind; that when found she was clothed in furs ornamented with the feathers of birds. Doubtless this

woman was the last survivor of the island tribes. As to the causes which led to the total extinction of this once populous race, there are no trustworthy data, and it would profit us but little to enter the wide field of speculation.

Of their manner of living little if anything is known. Cabrillo states that on most of the islands miserable huts existed, but on the mainland there were houses similar to those of the Indians of New Spain. On one of the islands, however, which he states was four leagues long, there were many good houses of wood. We are at a loss for further information on this point, but it is certain that the dwellings of these people were constructed of perishable materials and not of adobe bricks like the Pueblo Indians of New Mexico, since no trace can be discovered of such material, and it is hardly possible this would be the case in the short space of time since Cabrillo's visit. It is extremely probable, therefore, that they built their houses of timber, or else used the skins of animals slain in the chase. Referring to the matter of houses of wood upon the islands, some doubt might apparently be thrown upon this portion of Cabrillo's narrative, for at present no trees of a size sufficient for building purposes are found on the islands; but this author states that on the Isle de St. Augustin he saw trees 60 feet in height and of such girth that two men could not encircle them with their arms joined.

In their choice of localities for towns these ancient people showed the same degree of sagacity as that evinced by the American aborigines down to the present day. On the islands were myriads of water-birds and quantities of sea-lions and seals; the water fairly teemed with fishes and molluscous animals, affording a plentiful supply of food, and no doubt at the time they were occupied there was plenty of sweet water to be had, which, unfortunately, is not the case at present. On the mainland, at all the localities visited, the circumstances of environment must have been such as to render the struggle for existence extraordinarily easy. For instance, at Santa Barbara and up the coast, or what was called the Pueblos de las Canoas, the land is extremely fertile, and must have yielded good crops, for Cabrillo especially mentions that the Indians lived in a fertile valley, and had an abundance of corn and many cows. In addition to their pastoral pursuits, the Santa Inez Mountain afforded them game, and the waters, fishes, clams, mussels, &c. From the great quantities of shells found in the graves and kitchen-heaps, and the absence of mammalian bones in any quantity, it is fair to suppose that the tribes living near the seaside derived the greater portion of their sustenance from the waters. The favorite places for towns appear to have been not far from groves and near small mountain-streams. Anterior to 1542, these Indians must have been idolaters, but we have good reason for believing that after the advent of the mission priests many of them embraced the Roman Catholic religion, and faithfully followed its teachings. Cabrillo speaks of having seen on one of the islands (probably San Miguel) a temple of wood with paintings on its walls, and idols. San Miguel and some of the other islands have been carefully searched for this temple, but in vain.

It is hardly necessary to refer again to the different utensils found in the graves of these people, but it may be well to state that all the ollas, mortars, cups, pipes, and pestles met with were fashioned out of steatite, or magnesian mica, a sort of soapstone, consequently very soft, which alone was used for the ollas, sandstone of different degrees of hardness for the pestles and mortars, and serpentine for the cups and pipes. It is easy to understand that the ollas were readily carved from the soft soapstone-like material by means of stone knives, but how the gigantic and symmetrical mortars were hewn out with such rude tools is beyond our comprehension; yet they must have been easily procured, otherwise such lavish generosity in burying them with the dead would hardly have been possible. It is thought that the steatite articles were not made by the mainland Indians since no deposits of this mineral were at their disposal, but by the dwellers on the islands of Santa Catalina and Santa Rosa, where alone this mineral existed, and the supposition is that the islanders trafficked with those of the mainland for their commodities, giving in exchange utensils of steatite. The ollas were doubtless used for cooking, as many of them bear marks of fire, and the mortars for bruising grain, acorns, and grass-seeds, the smaller cups and basins for ordinary household purposes, and the pipes for smoking. Canoes are mentioned by Cabrillo, who states that some were small, holding only two or three persons, while others were of sufficient capacity for ten or twelve. These were probably hewn, not burned, from logs of redwood cast up by the waves. The one mentioned as discovered by our party containing a skeleton was, however, formed of three planks, which had been lashed together by sinew or cord, the joints being payed over with asphaltum. The ornaments and beads of domestic manufacture were made of the nacre of shells and of small shells, but the glass beads found were undoubtedly of European workmanship. There seems but little doubt that nets were used for trapping fishes, a small portion of what appeared to be mesh-work being found. Furs are spoken of as articles of clothing in Cabrillo's narrative, but beyond this nothing is known. In speaking of the employment of furs, mention is made of the long, fine, black, and beautiful hair of the natives; this statement is corroborated by the appearance of some hair found on the skull which we have spoken of as being found covered with a copper pan.

It was at first supposed that a certain design had been followed in the manner of interment, or rather of the posture in which the bodies were placed, but an examination of the notes already given will show that such was not the case, although most of the entire skeletons discovered at La Patera were in the same position, but those at Dos Pueblos were in all attitudes, consequently we infer that there was no regular mode of procedure. From the fact that so many loose and broken bones were found close to the surface of the earth, it is probable that the same spot had been used over and over again for burials, the remains of the previous occupants being shoveled out to make room for new-comers. Perhaps the utensils disinterred were also made to serve for more than one burial. A question in connection with the burials, which is yet to be satisfactorily answered, is, How were these people enabled to pass the heads of children, and even grown persons through the narrow openings in the ollas except in a mutilated condition. It is true that some savage tribes expose the bodies of their dead until the flesh is removed, but we know of no instance where savages are in the habit of cutting up their dead for burial purposes. It may be these people practiced the cutting method, or that finding bones in digging anew, these were thrown in the ollas simply as a ready means of their disposal.

In addition to the burial localities already mentioned, we are cognizant of others to the northward and southward of Santa Barbara, and quite a number of them have already been explored, although doubtless others still remain *perdu* to excite further archæologic cupidity. Mr. Paul Schumacher has examined a number in the vicinity of San Luis Obispo and on the Santa Maria River, and Mr. Bowers quite a number in Santa Barbara and in the vicinity of Carpenteria, lying south of this city.

We have carefully consulted all available works which would tend to throw light on the history of these aborigines, but, with the exception of the narrative of Cabrillo, have found little pertaining to the subject. It may, perhaps, be interesting to give the full title of the rare and most entertaining manuscript from which we have so freely quoted, which was reproduced in typography by the late Buckingham Smith, in his work entitled | Coleccion | de varios documentos | para la historia de la Florida | y tierras adyacentes:

Cabrillo's own title, or rather Ferrel's, is as follows: "Relacion, ó diario de la navegacion que hizo Juan Rodriguez Cabrillo con dos navios al discubrimiento del paso del mar del sur al norte, desde 27 de Junio de 1542 que salio del puerto de Navidad, hasta 14 de Abril del siguiente año que se restituyo á el, haviendo llegado hasta el altura de 44 grados, con la descripcion de la costa, puertos, ensenados e islas reconocio y sus distancias, en la estenscion de toda aquella costa." The death of Cabrillo, as already stated, occurred on the Isla de la Posesion, in the middle of January, 1543, and was caused by injuries received from a spar which fell from aloft and broke his arm near the shoulder. Before his death, he named as his successor Bartolome Ferrel, "Piloto mayor de los dichos navios," and to this successor we are indebted for all we know of the people under discussion.

In conclusion, it may with propriety be stated that we have here only endeavored to show the results of the exploratory work performed in the vicinity of Santa Barbara by the party sent out under the auspices of the expedition in your charge, and that no attempt has been designed toward solving questions appertaining thereto, more particularly in view of the fact that the entire subject will be fully and ably discussed by Professor F. W. Putnam, of the Peabody Museum of Archæology, Cambridge, to whom the entire collection has been submitted for examination and study, and who is perhaps better fitted for this most entertaining task than any other person in the country. In his hands we willingly leave the subject, confident that, with the rich materials gathered by us as a basis, he will elucidate many hitherto mysterious problems connected with the customs of this extinct race, and bring to light much of their now hidden history.

APPENDIX H 14.

NOTES UPON ETHNOLOGY OF SOUTHERN CALIFONIA AND ADJACENT REGIONS, BY DR. O. LOEW.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., February 19, 1876.

DEAR SIR: I have the honor to submit herewith a report upon the Indian tribes visited, their customs and relations, as well as old hieroglyphical writings upon rocks in Mono County, California. As ethnology is a matter of steadily increasing interest, I hope this contribution will not be without its value.

Very respectfully, your obedient servant,

OSCAR LOEW.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in Charge.

During the field-season of 1875 you kindly gave me an opportunity to visit a number of localities in California that did not lie directly upon the route of Lieutenant Bergland's party, to which I was attached, and I therefore availed myself gladly of any occasion to collect facts upon ethnology whenever the regular duties permitted me to do so.

While on the expedition of Lieut. Bergland's party, the Payutes of Southern Nevada, the Hualapais of Northwestern Arizona, the Mohaves and Chemehuevis of the Colorado River Valley, the Kauvuyas and Takhtams of the vicinity of San Bernardino, were visited; and before the expedition started out, the Mission Indians of Santa Barbara and San Gabriel; and after the return from the field to Los Angeles, the Indians of San Juan Capistrano, San Diego, and of Mono and Inyo Counties, California. Vocabularies comprising from 200 up to nearly 400 words, and also sentences that may assist in establishing certain grammatical rules,* were collected of those languages, of which some have almost died out and now spoken by very few individuals, as is the case with the Kasuá of Santa Barbara and the Tobikhar of San Gabriel.

While of some of the languages (Mohave and Chemehuevis) a long list of words was collected by Lieut. A. W. Whipple during his exploration for a Pacific railroad route in 1853; of others, over two to three dozen words were barely known, as with the languages of San Diego, San Juan Capistrano, and San Gabriel. Of others again, no vocabularies had been published to this time, viz, Kasuá, (Santa Barbara,) Takhtam, (Serranos of San Bernardino,) and the Western Payutes, (Mono and Inyo Counties, California.) Hence I trust that the collection of vocabularies and sentences now made will prove of value and fill a gap in the philological knowledge of Indian idioms.

THE MISSION INDIANS.

The pious zeal of the Spanish priests drove them soon after the religious subjugation of Mexico into Southern California, but up to the end of the seventeenth century they had but little success; many were murdered, stoned to death, or cremated alive. It was mainly in the eighteenth century that they gained considerable headway. Some of the mission churches were built in the present century; that of San Juan Capistrano in 1806, destroyed by an earthquake in 1812, has remained in ruins ever since; and that of San Bernardino was built in 1822, whose ruins are now used for a sheep-corral. *Sic transit gloria mundi!* Nearly all the missions, hardly over forty in number, were in the coast counties. The most important of them were San Diego, San Juan Capistrano, San Luis Rey, Los Angeles, San Fernando, Santa Barbara, San Luis Obispo, and Monterey.

The Mohaves, Yumas, and Cocopahs resisted all attempts at conversion; they could not conceive the sometimes contradictory teachings of Loyola's followers, who preached different morals from what they practiced, and it appears that the Mohaves, like the Moquis, became the more averse to the Christian religion the greater the zeal and energy of the Jesuits in forcing their belief upon them.

The *Padres* generally tried to eradicate the original name of the tribes and substitute Spanish ones; the tribe of San Diego, for instance, is known under the name Diegueños, and their original name is forgotten, but, as the language indicates, the tribe forms a branch of the Yuma stock. Just north of this tribe lives another, but speaking a very different language, and without a uniform tribal name. They occupy about a dozen ranches† situated between the coast and the Coahuila Valley. The tribal name Netela, mentioned by Buschmann appears to be unknown there, at least all my questions were answered in the negative by the Indians of San Juan Capistrano and San Luis Rey. The former call themselves Akhátchma, the latter Gaitchim, (the Ketchis of Buschmann,) but the Spanish names have here also taken root, the names San Juaneños, San Luiseños, &c., being frequently used. Their language is closely related to that of the Kauvuyas, (Cowios, Coahuillas,) who live just east of the former, and occupy a number of ranches in the San Jacinto Mountains and the adjacent Cabezon Valley. The Kauvuyas had also been converted by the Jesuits, and belonged, with the related tribe of the Takhtams,‡ to the mission of San Bernardino. One of the Kauvuyas told me that their forefathers used to burn their dead, but the padres abolished that practice, saying that "the Great Spirit would be displeased," (se enojaria Dios.) These Indians raise corn and watermelons, and serve as laborers with the whites.

Another tribe lives at San Gabriel, a town nine miles east of Los Angeles, but the full-blood, as well as the half-breeds, use more of the Spanish language than their own, which is known to some extent only by the two old chiefs living there. The name Kizh, given by Buschmann to this tribe, could not be verified with all my efforts; if this tribal name ever existed, it is now entirely forgotten. The old chief I visited called his tribe Tobikhar, or Spanish, Gabrileños. He was probably over ninety years

* The reader is referred to Gatschet's paper in this report. (App. H 16.)
† Among them the lately much talked of Temécula.
‡ Their Spanish name Serranos signifies "inhabitants of the Sierra."

of age, very weak, and suffering from a painful eye-disease. Among other statements he said that he had made a treaty with General Frémont in 1843. Many words I propounded to him he could not recall in his native language, and excused himself by saying, "we are now so far civilized that we have forgotten our own language," (somos tan civilisados que hemos olvidado nuestra lengua.) Still the collection of words obtained comprises about 200.

Another language nearly extinct is that of the Indians of Santa Barbara, on the coast. After much inquiry, an intelligent Indian * about three miles north of the town was found, who owned a large farm, and spoke, besides his own language, tolerably well Spanish and English. He called the original tribe Kasuá. The ruins of the old mission church are about three miles east of the town.

THE UNCONVERTED TRIBES.

One of the most numerous tribes in North America is that of the Payutes.† Indeed, this tribe, the main stock of the Shoshone family, has ramifications that reach very far. From the Mohave River ‡ in Southern California to Central Utah, from the Moqui towns to the northern boundary of Nevada, they are distributed in larger or smaller bands across valleys and mountains, and have many dialectical differences of language. While the party was encamped in the Colorado River Valley at Cottonwood Island, a great number of Payutes came daily into camp, and occasion was taken to collect over 350 words and many sentences; an easy matter if one meets an Indian speaking well Spanish or English. The vocabulary was again compared at El Dorado Cañon and Stone's Ferry.

The Chemehuevis live farther south, near the mouth of Bill Williams Fork, in the valley of the Colorado River. Their language is nearly identical with that of the Payutes of Southern Nevada. However, the language of the Payutes of Inyo and Mono Counties, California, shows very considerable differences; again, the dialect of Aurora, Nev., is differing considerably. The distinction is therefore made between the Southern Payutes, living in Southern Nevada and in the Colorado River Valley below the mouth of the Grand Cañon, and the Western Payutes, living in Mono and Inyo Counties, California. The Payutes are but little devoted to agriculture, some families raising watermelons, being exceptional cases. Their principal food consists of mesquite, beans, pine-nuts, lizards, vermin, grasshoppers, occasionally rats and rabbits, still rarer a deer or a mountain-sheep forms means of subsistence. Fish are not eaten because of a superstition. The Southern Payutes, who have, like the Mohaves, four blue tattooed vertical stripes on the chin, used to be a dangerous tribe. Camp Cady, on the Mohave River, was established on their account, and in a most desolate uninviting region; but the post was abandoned several years ago, the Indians having gone to the Colorado River. In 1864, over two hundred Payutes were surrounded at Owen's Lake by a party of whites and all drowned.

A tribe much superior to the Payutes is represented by the Mohaves, devoted to agriculture and but little to hunting. Lieut. A. W. Whipple, 1854, was the first who published details of the customs and language of this interesting tribe. This officer also selected the spot for the establishment of a military post in that region, and Fort Mohave was soon afterward built there. The Mohaves have seldom been troublesome to the whites, and the latter have in such cases been the cause of difficulty. In 1859, they killed some emigrants who had stolen corn and watermelons from their fields, which caused a fight between a company of soldiers under Captain Armistead and a band of Mohaves, whereby the former were repulsed and would have suffered heavy loss had not succor arrived from the fort at the critical moment. This tribe numbers about 3,000 souls, and is one of the tallest on the continent, surpassing in height the hunting tribes of the Payutes and Hualapais, the latter speaking a tongue closely related to Mohave and inhabiting the cool mountain regions of Northwestern Arizona. The Colorado River Valley, from Fort Mohave about 200 miles to the southward, with a very hot climate in summer-time, was the home of the Mohaves for many generations past. They live principally as vegetarians, using meat but very rarely. The Mongolian features are more marked with the Payutes than with them. The color of the skin is light-brown, their countenance is rather pleasant and even intelligent, and the physiognomies differ as much as among the white race. The front teeth are worn down to one-half the usual size, and flattened, showing that they are much used in masticating food. Bad teeth appear to be unknown there. In summer-time they live in open huts, in winter in holes dug in the ground and covered with branches. They have names for constellations, for some even the names of animals, a singular coincidence with the idea of the old oriental nations. Thus the Orion is called *amó*, (mountain-sheep;) Ursus Major, *hatchá*; Milky way, *hatchil-kuya-avunyé*, (trail of heaven;) Venus, *hamosé*

* His Spanish name was Vincente Garcia.

† Spelled in various ways: Pa-utes, Pi-utes, Pai-utes, Pah-utas.

‡ They left the Mohave River but three years ago.

valtai, (the big star;) Jupiter or Saturnus, *hamosé kavotanye.* According to the position of the "Great Bear" they judge the time at night, and know that its position is a different one at sunset at different times of the year.

The language is polysyllabic, melodious, and rich. There exist four words for "to eat," according to the food, and three words for "ant," according to the species: *Tchama thulye*, (little piss-ant;) *Hano-pó oka*, (large hairy ant;) *Horó-o*, (little black ant.) They have a separate word for "thinking," *alieta*, and in expressing it put their fingers to the forehead, knowing well that brain-work and thinking are identical. Some of their words have eight syllables, for instance, *melage-génya-hanólye*, the throat-bone, thyroid cartilage. Although they have no law against polygamy, most of them have but one wife. The women are well treated, and by no means like slaves, a moral feeling in the families generally being observed. Of course there are exceptions to the rule, exceptions that become conspicuous with those Indians that live just around the white settlements.

The Mohaves have a myth of a great flood, during which their forefathers lived upon the neighboring mountains. They are very superstitious. Dreams are ascribed to the influence of deceased friends. If one dies upon a trail, his spirit will hover there to harm those passing by at night. To avoid this, another trail is made, leading far around the bewitched spot. After the death of a man, the whole family bathe for four days, with little interruption, in the river, and a horse is killed in order to enable the spirit to ride to heaven. The heaven, *okiámbova*, is situated in a *hot* and dry valley west of the Mohave range; while the hell, *avikvomé*, is on the top of a big mountain where it is cold and rainy, (Dead Mountain, forty miles north of Fort Mohave.) They believe in a good and bad spirit. The custom of cremation is very old with them. Upon inquiry why the dead are not interred, as among white people, they laughed, and said, "It stinks bad." During the ceremony, all the clothes of the deceased and of his relatives are burned. If a medicine-man predicts three times falsely he is invariably strangulated. Several year ago such a medicine-man was only saved by the interference of the military authorities of the post. Another provided himself with a pistol, having resolved not to submit to the punishment for his unfortunate diagnosis.

COMPARISON OF LANGUAGES.—HIEROGLYPHICAL WRITINGS.

As to the origin of the Indians, many theories have been offered, of which the most probable is that of Asiatic descent; especially the marked Mongolian features of some tribes are favorable to this conception, so ably treated by Mr. H. Howe Bancroft in his "Native Races of the Pacific States," and by Oscar Peschel in his "Voelkerkunde," to which works the reader is referred. What I desire to call attention to, however, are several points not heretofore treated with the desirable minuteness, chiefly on account of want of proper knowledge of some of the Californian languages; I mean affinities between some of the idioms with the Japanese and Chinese. It is true some attempts have been made to prove a relationship between a Mexican language (Otomé) and the Chinese; however, those efforts become ridiculous to the eye of the critical examiner.*

When collecting vocabularies in Southern Califarnia, I was struck with the Kauvuya word *tam-yat*, for sun, resembling much the Chinese *yat-tau*, for sun. This led me to compare all the vocabularies I collected on your expeditions with Japanese and Chinese, with which languages I am acquainted to some small extent However, it was with the apprehension of touching a field outside of my sphere that I commenced this work. I therefore declare expressly that I leave it to the professed philologist to decide whether the similarities of words contained in the following table are to be ascribed to accidental coincidence. I further declare that among the eighteen languages of California, New Mexico, Nevada, and Arizona, compared with Japanese, only the Payute offered some striking similarities of words with this idiom†. About one dozen more words could be added than contained in the following table, but as the similarities between these words are confined to one single syllable, they were discarded.

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* See Bancroft, Native Races, vol. iii.

† About infusion of Japanese blood into the California Indians, and drifting of Japanese vessels from the Asiatic to the American coast, see Bancroft, Native Races, vol. v, p. 52.

Table showing Indian words similar to Chinese or Japanese.

nglish.	Chinese.	Japanese.	Southern Payute and Western Payute, and Mōqui.	Mohave.	Takhtam and Kauvuya, (San Bernardino, Cal.)	Gaitchim, (San Juan Capistrano, Cal.)	Tobikhar and Kasuá, (San Gabriel and Santa Barbara, Cal.)
woman	nu		na-intsi, (S. P.)			nu-itmol	nurt, (To.)
child		ko					ko-ar, (To.)
head	tau		tatsiv, (S. P.)				
hair	mo			mo-gora			
face		omote	muta-gav, (S. P.)				
belly	to			i-to			
heart	sum				he-son, (Kau.)	mo-shun	san-tugh, (Kas.)
house	uk, kan*		gan, (S. P.)				
finger	shau-tchi†		malatchi, (Mōq.)				
arrow		ya			hu-yal, (Kau.)		ya, (Kas.)
heaven		ama		amaya			
sun	yat, or yat-tau		tau-vabits, (S. P.)		tam-yat, (Kau. and Ta.)		tamet, (To.)
star		fosi	potsiv, (S. P.)	hamosé	ho, (Ta)		
wind	fung					hı	
bark		kava	voa-kave, (W. P.)		akav, (Ta.,) (Cal.)		
grass	tso						tsu-ege, (Kas.)
insects { beetles / crickets }		musi	mubits, (S. P.)				
grasshopper		hata-hata	huá-tata, (W. P.)		huó-hata, (Jemez)		
large	tai	tai		vat-tai			
small	siu	tsito	tu-u-tsi-e, (W. P.)				
very		hana-hada		tahana			
to make	tso	tsu-kuri	tsa-rai, (S. P.)				
to laugh		varai		tchego-varum			
quick	fai	haya			havun, (Kau.)		

* Used as numerative or classifier of houses.

† The sons of hand.

In preparing the foregoing list, 350 words of Payute and Mohave served for comparison, and from 200 to 300 of the others. The similarities of words for *sun*, *star*, and *heaven* are certainly remarkable.

In comparing a number of otherwise totally different languages of the West, we are struck by the fact that a few words, especially for *water*, *hand*, and *bird*, seem to have the same roots in most of them; moreover, roots we find again in other countries.

In comparing the word for *hand*, we find—

Name of tribe.	Country.	Word for "hand."
Tehua	New Mexico	*ma*.
Taos	do	*ma*nena.
Querez	do	shka-*ma*stsi.
Isleta	do	*man*.
Jemez	do	*ma*-tash.
Moquis	Arizona	*ma*-khde.
Aztec	Mexico	*ma*-itl.
Ute	Utah	*mû*.
Payute	Nevada	*mo*-om.
Tobikhar, (San Gabriel)	California	a-*man*.
Kauvuya	do	ne-*ma*-to-e.
Gaitchim	do	ne-*ma*-vuitchaig.
Digger	do	se-*mut*.
Wihinasht*	do	i-*mai*.
Neeshenam*	do	*ma*.
Meidoo*	do	*ma*-*ma*.
Shoshone	Nevada	*ma*-shitu.
Comanche	Texas	*ma*-shpa.
Cahita	Mexico	*ma*-*ma*.
Cora	do	moa-*ma*-ti.
Lombok†	Java	ii-*ma*.
? †	Hawai Islands	li*ma*.
? †	Timor Islands	li*ma*.
? †	Celebes Islands	li*ma*.
Tonga †	Friendship Islands	li*ma*.
? †	Formosa Islands	ri*ma*.
? †	New Zealand	bali*ma*.
? †	New Guinea	li*man*gh.
Satahuan†	West Polynesia	galei-*ma*.
Saparua†	Molucca Islands	ri-*man*i.
Caffre†	Africa	*man*dha.
Romans	Italy	*man*us.

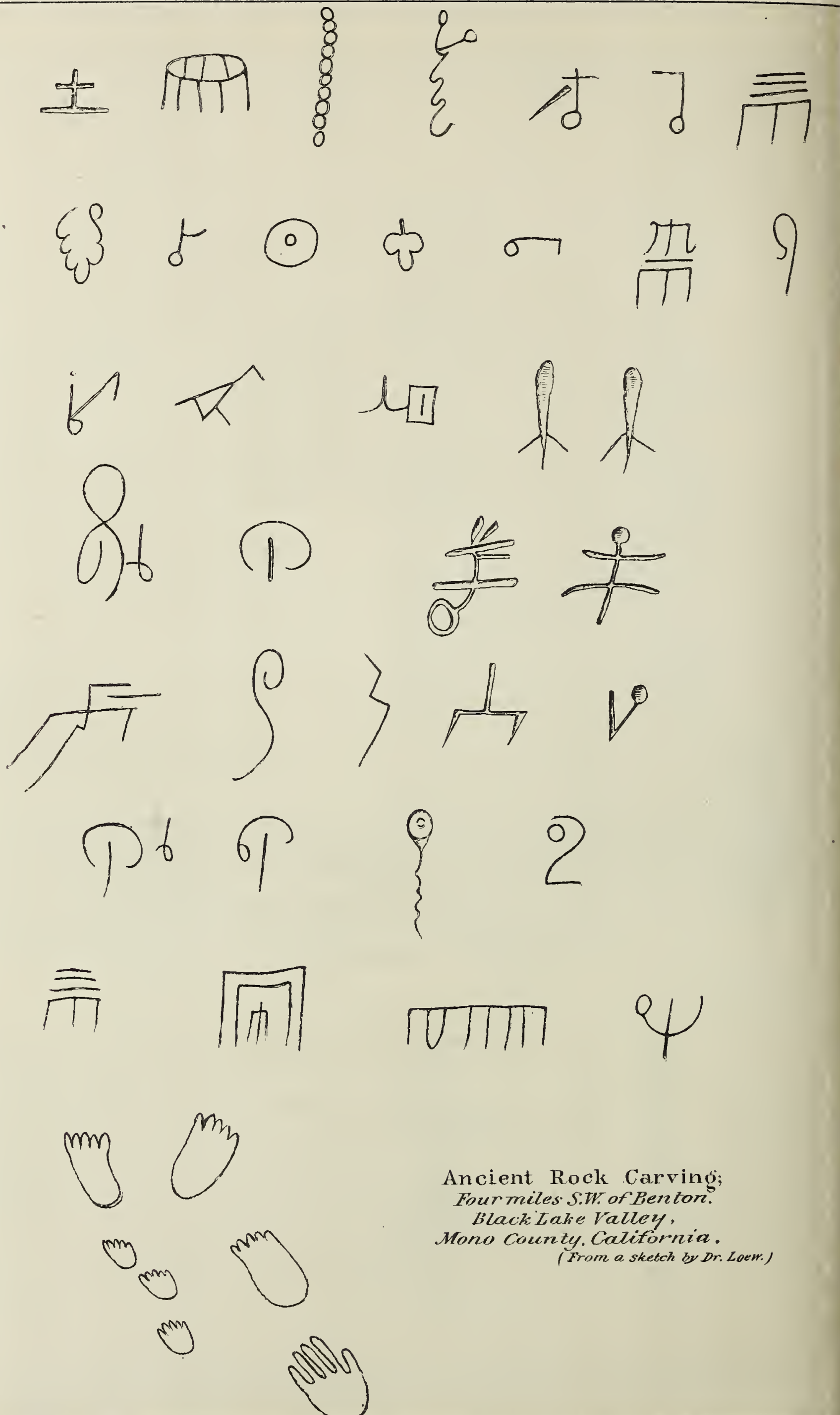
* Taken from Bancroft, "Native Races," vol. iii. † Taken from Balbi, Tableaux des Langues.

While the syllable *ma* for *hand* can be traced in America as far south as Brazil, it is not found with Indians east of the Rocky Mountains, nor with the Esquimaux. Of the eighty African languages I compared, only the Caffre language contains it again.* Neither is this syllable found in the Semitic, Finnish, Bas Basque, Caucasian, Central and North Asiatic languages, nor in the Sanscrit, (*hasta*,) but again in the Latin word *manus*. As regards Chinese (*hand* = *shau*) and Japanese, (*te*,) the analogy is wanting; but there is a word in the latter language, *mai*, meaning a handle.

Another word common to a great many Indian languages is that for *water*.

Name of tribe.	Country.	Word for water.
Payute	Nevada	pa.
Kauvuya	California	pal.
Gaitchim	do	pal.
Ute	Utah	pa.
Tobikhar	California	par.
Isleta	New Mexico	pa.
Jemez	do	pa.
Tehua	do	po.
Weithspek	Oregon	pa-ha.
Mohave	Arizona	aha.
Sidney	Australia	bado.
Abai	Philippine Islands	bahi.
	Java	pa-niu.
Zend	Persia	apo.
Sanscrit	India	apa.
Guzerate	do	pani.
Roumains	Wallachia	apa.
Cholo	Central America	pay-to.

* These remarkable resemblances appear to give support to A. Murray's geological hypothesis of a now submerged continent in the Indian Ocean, the supposed cradle of mankind.



Ancient Rock Carving;
Four miles S.W. of Benton.
Black Lake Valley,
Mono County, California.
(From a sketch by Dr. Loew.)

Like the syllable *ma* for *hand*, so is the syllable *pa* for *water* wanting in the Indian languages EAST of the Rocky Mountains. This syllable is *not* found with the Semitic, Central Asiatic, nor African languages.

In the Chinese *shui* and the Japanese *mitsu* we miss the resemblance; but in both languages occur words with a certain relationship: in Japanese *pai* means a drinking-cup, the Chinese *pui*.

Furthermore, the syllable *tsi* for "bird" occurs in almost every Indian language west of the Rocky Mountains; again, the same syllable *tsi* means "male birds" in Chinese, as well as Japanese.

The formation of the plural in Payute is nearly the same as in Japanese; both languages use the syllables *bara* and *gara* to express the plural form:

Payute:	gan (house.)	Plural,	ganigara.
	kanab.		kanabara.
Japanese:	fito (man.)		fitogara.
	matsu (fir.)		matsubara.

Again, the *pre*positions become *post*positions in both languages.

Payute:	nuni	gan	upa	ne.
	I	house	in	am.
Japanese:	watakusi	iye-no	utsi-ni	ari.
	I	house	in	am.

If the Indians are of Asiatic origin, it is but natural that, if an affinity to Asiatic nations is traceable at all, the most success would be expected in examining those tribes that are still in closest proximity to the Asiatic coast; that is, the tribes of the Pacific States.

Historical facts are unfortunately not known proving these migrations, but the possibility cannot be questioned. That, however, in comparatively recent time, that is, in the beginning of our era, Japanese and Chinese visited the American coast is beyond a reasonble doubt. An old Chinese work relating to the discovery of a country 20,000 li to the eastward, by the Buddhist priest Hoei-Shin, has been translated, and given rise to much discussion.*

In connection with this, it may be interesting to reproduce here a singular inscription containing several distinct Chinese characters on basaltic rocks in Black Lake Valley, about four miles southwest of the town of Benton, Mono County, California. Mr. Richard Decker, of the town, called my attention to this inscription. Certainly, I never saw a similar one in New Mexico or Arizona. Should the striking resemblance of some of the charcters to Chinese symbols be a mere accident, or give proof of early Chinese explorers? The inscription is scratched in the basalt surface with some sharp instrument, and is evidently of great age.

The Indians say that it was a mystery with their fathers who made these inscriptions. The rocks upon which they are seen lie regularly upon each other; and the true order of sequence of the symbols cannot be ascertained. The latter are from 3 to 5 inches high.

The Chinese-resembling symbols in the inscription are the following:

No. 1.—土 = to, the earth.

No. 2.—扌 = shau, the hand, (contracted form.)

No. 3.—示 = shi, an omen.

No. 4.—乚 = min, a cave, a house.

No. 5.—冂 = kwang, a desert, and 丅, kan, the clothing.

The direction of the feet at the bottom of the page giving the description is exactly toward the northwest.

About 20 miles farther south from this locality exist two other similar inscriptions, according to Mr. Richard Decker, aforementioned.

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* The reader is referred to the recently published work "Fusang, or the discovery of America by a Chinese Buddhist priest in the fifth century," by Charles G. Leland. The work is very ably written. It contains but one remark from the author with which I cannot agree, when he speaks, page 136, of Coronado and the "Quivira River" in connection with *Northern California*. We know that Quivira was a town in *Eastern New Mexico* visited by Coronado in 1542. Coronado never was in California.

APPENDIX H 15.

ON THE PHYSIOLOGICAL EFFECTS OF A VERY HOT CLIMATE, BY DR. O. LOEW.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF ONE HUNDREDTH MERIDIAN,
Washington, D. C., February 9, 1876.

DEAR SIR: I have the honor to submit herewith a report upon the physiological effects of a hot and dry climate, a subject deserving attention in connection with the exploration or occupation of the Colorado Valley, and one not heretofore treated upon to any great extent.

Very respectfully, your obedient servant,

OSCAR LOEW.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in Charge.

It is in but comparatively few regions of the earth that the temperature of the air rises above blood-heat for weeks and months in succession; hence, our knowledge of the physiological changes produced by it are quite meager.

When it is considered that under ordinary circumstances the whole tendency of the human system is directed toward keeping its temperature *above* that of the surrounding air, the task is suddenly reversed in the hot deserts, where the thermometer rises for considerable periods daily up to 110° to 116° F., in some cases up to 120°, while the normal temperature of the blood is 98°.5 F. That this task is at first not solved with precision is because the system only gradually accommodates itself entirely to the new conditions, and apparently after losing twelve to fifteen per cent. of its bodily weight. What a change in the conception of hot and cool is undergone in such a climate, when it is found *agreeably cool* in the evening, when the thermometer has descended from 110° to 94° F.! Observations on pulsation and respiration were frequently made, and it was found that the former was generally much increased, while the latter showed but a slight, sometimes no increase.

The following table shows some of these observations:

	July 30.		July 31.	
	Pulsation.	Respiration.	Pulsation.	Respiration.
A	75	23	80	18
B	78	16	89	25
C	73	19	80	21
D	80	14	65	22
E	76	18	72	28
F	56	12	60	17
G	72	18	....	....
H	96	18	....	....

The temperature of the air was 108° F. in the afternoon when the observations were made. G and H were two Payute Indians, who came into camp, one of about twenty-five, the other about sixty years of age. On July 31, a hot wind was blowing all the afternoon, and the observations were made after a march of 15 miles to El Dorado Cañon, on the Colorado River. A, B, and C, were at work upon the mesa and exposed to the hot sun and wind, while D, E, and F had taken a bath in the river and remained in the cool shade on the shore. F was a very phlegmatic person, and his pulsation and respiration were always lower than the others. The normal number of respirations during the day is considered to be 18 per minute; that of pulsation 60 per minute.

The temperature of the body was taken on various occasions and found, to be increased in very hot afternoons about 1° F., but at one time, after a march of 20 miles in a scorching heat, it was found with B increased fully 2°, (taken under the tongue.)

If it is considered that the temperature of the body is but 98.°5 F., it must be a matter of surprise that in a heat of 110° to 116° F. it is not increased more than one or two degrees above the normal temperature, although inner heat is being produced by breathing and oxidation that is continually going on in the blood. The system has, therefore, to contest against two sources of heat, the interior and the exterior.

That a decrease in the assimilation of food forms one condition is doubtless true; but he principal factor is an enormous evaporation from the body, which to determine

quantitatively appeared a matter of great interest. From a series of observations made during very hot days, (108° to 114° F.,) measuring the amount of water drank and the volume of urine secreted, the conclusion was arrived at that two liters of water leave the body in the gaseous state during the twelve day hours. If, however, engaged in heavy work, such as packing mules, climbing mountains, &c., the amount is nearly doubled. The volume of urine was found to average only one-twelfth to one-fourteenth of water drank. The latter had generally 70° F.; but that the lower temperature of the drinking water has but very little to do with the cooling of the body may be shown by the following calculation:

Let it be supposed that a man of 70 kilograms weight drinks 2 liters of water of 70° F., and that the specific heat of flesh is the same as that of water, which is very nearly correct, as the body consists of about 75 per cent. of water, we have the following equation:

$$\frac{70 \times 98.5 + 2 \times 70}{72} = 97.7$$

The blood temperature would therefore be decreased to 97°.7 F., or not more than 0.8°. That this is not sufficient cooling effect for twelve hours in such a hot climate is evident. But how different the result if we calculate the amount of heat becoming latent by conversion of two liters of water into vapor! According to Regnault, the latent heat of one gram water converted into vapor of a certain temperature is expressed by the following formula:

$$W = 606.5 + 0.305\ t.$$

t is here the temperature of blood-heat = 36°.8 C., (98°.5 F.) Hence, the number of calorics = W, becoming latent by evaporation of two liters of water, is equal to 1,235,000; which, should the evaporation suddenly take place, would suffice to depress the temperature of the body (70 kilograms weight) for 17°.6 C., or 31°.7 F.! But this cooling effect does not take place at once; the two liters evaporate gradually during twelve hours; hence, the cooling effect per hour is = 2°.6 F. This, therefore, would be the amount which the temperature of the body would be raised if no more water were available for evaporation.

How soon a person must succumb from thirst in such a hot climate becomes evident. The first symptom is delirium, and when arrived at that state the efforts to save are rarely crowned with success. A number of cases were related to me where helpless sufferers have been picked up, but died after one or two days, in spite of all care bestowed upon them. Even old pioneers, miners in the mountains, who were well acquainted with the dangers of crossing the desert in a new direction, deviating from the old trails leading to water, perished, overcome with thirst and fatigue; not by sunstroke, which is almost unknown there. It appears that this latter calamity only takes place when the hot atmosphere is at the same time charged with humidity, interfering with the free evaporation from the body.

It is evident that by drinking large quantities of water, the blood must acquire a high degree of dilution; hence all the juices, those of digestion included, the gastric and pancreatic, must be more diluted than usual, and the power of digestion weakened. Therefore, but a limited amount of food is assimilated, no matter how much is eaten, and a great deal leaves the body undigested, with the feces, which generally are of a thin consistency.

As another consequence we observe the decrease of muscular power; every exertion requires an increase of combustion, whose result, the heat, has to be converted into mechanical force. But everything tends here to keep the combustion at a low state. Hence it is preferable to be vegetarian in this climate, as a consumption of meat produces an increase in the number of blood-corpuscles, the absorbers and carriers of the oxygen, the oxidizing surface. The Mohave Indians inhabiting the hot Colorado Valley below Fort Mohave are exclusively vegetarians.

It is worth mentioning that after consuming fatty matter a considerable portion is exuded unchanged by the skin. It was also observed that while meat increases the thirst immensely, fat suppresses it considerably. Repeatedly I was assured, that in crossing the desert, alcoholic drinks and tobacco have a very injurious effect, as a person using them succumbs much sooner. A resident of Saint Thomas, a little oasis on the Muddy Creek in Southern Nevada, stated that two or three days previous to undertaking a desert trip he abstained from any stimulating material.

It is a question of interest in what proportion stand the quantities of water evaporated by the lungs and by the skin.

The average volume of air inhaled during twelve hours is, according to Carpenter's Physiology, 5,000 liters. This volume leaves the lungs perfectly saturated with moisture* at blood temperature; hence the maximum amount of water removable by exha-

* At least in the hot desert climate, where the inhaled air is hotter than the body. The repeated introduction of the wet bulb of the psychorometer into the nostrils substantiated this fact.

lation is 210 grams. We have seen above that two liters = 2,000 grams evaporate from the body in twelve hours. Hence the remaining 1,790 grams must take their way through the pores of the skin, and the quantities stand in the proportion as 1 : 8.5, while under ordinary circumstances the relation is but 1 : 0.66 (!).

It appears, therefore, that the main evaporation, hence the main cooling effect, takes place by the skin, and that evaporation by the lungs exercises but little influence on the temperature of the body.

APPENDIX H 16.

ANALYTICAL REPORT ON ELEVEN IDIOMS SPOKEN IN SOUTHERN CALIFORNIA, NEVADA, AND ON THE LOWER COLORADO RIVER, THEIR PHONETIC ELEMENTS, GRAMMATICAL STRUCTURE, AND MUTUAL AFFINITIES, BY ALB. S. GATSCHET.

NEW YORK CITY, *April* 3, 1876.

SIR: I have the honor to submit herewith a linguistic report on the subject of Indian languages, of which vocabularies and sentences have been collected by members of your survey during the summer months of 1875. These idioms are enumerated in the order in which they were commented upon: the Kasuá, Kauvuya, Takhtam or Serrano, Gaitchin, Kizh, Southern Payute, Chemehuevi, Western Payute, Mohave, Hualapai, and Diegeño. Four of them, the Takhtam, Chemehuevi, Western Payute, and Hualapai, were, up to this day, only known *by name* to the scientific world.

In my report I took care to dwell mainly on such points as seemed most important from a linguistic point of view, and would give the best idea of the characteristics and peculiarities of each idiom. In two instances, where the affinity of the idioms were unknown or doubtful, I have tried to establish their genealogical connection by etymological comparisons with neighboring idioms.

A fact not mentioned in express words in my report is, that the commonly admitted affinity between the Yuma and the Pima dialects does not exist at all. Except a few similarly sounding terms, I have been unable to find any traces pointing in the direction of this theory, which was started only on account of the vicinity of both language-families; and, in fact, the Yuma stock of aborigines is thoroughly independent for itself, and disconnected from others, as well in race as in its form of speech.

I remain, sir, most respectfully, your obedient servant,

ALB. S. GATSCHET.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in Charge.

The territory visited in 1875 by that section of your expedition of which Dr. Oscar Loew was a member is inclosed by the Pacific Ocean on the west, the Colorado River on the east, and by the thirty-fifth parallel on the north. This wide-stretching, mountainous, or rugged section of Southern California is the abode of a number of Indian tribes, once numerous and powerful, whose dialects Dr. Loew has undertaken to study during the short stays made at each of the Indian settlements.

On examining carefully his notations, vocabularies, and collections of sentences, which extend over eleven idioms, I have arrived at the following classification:

The dialects studied by Loew belong to only *three distinct families* of aboriginal languages; to the Santa Barbara, the Shoshonee, and the Yuma family.

The *family of Santa Barbara* languages seems to extend only over a small portion of the coast and the interior, and a dialect of it was also spoken on Santa Cruz Island. Dr. Oscar Loew has studied the dialect of the *Kasuá*, also called Cashwah or Cieneguita Indians, near Santa Barbara.

The *Shoshonee family* extends over an enormous inland area, from the Columbia River, Montana, and the British Possessions, through the great interior basin, down to the southwestern corner of the United States. It comprises the idioms of the Bannocks or Pa-nasht, of the real Shoshonees or Snake Indians, the Utahs, the Pa-Utes or Payutes, the Kauvuyas or Cahuillos, the Comanches. Other languages, as that of the Kiowas and Moquis, have borrowed so extensively from the Shoshonee stock of words, that they appear to be dialects of that family.

The Shoshonee dialects studied by Dr. Loew in 1875 belong to two branches. Of the Kauvuya branch in California, he studied the Kauvuya, the Takhtam or Serrano, the Gaitchin or Kechi, and the Tobikhar; of the Payute dialects, he has transmitted notations from the Southern Payute and the Chemehuevi, spoken on Colorado River and west of it, and from the Western Payute, spoken in Mono and Inyo Counties, California.

The *Yuma family* of dialects has received its denomination from the most populous of all the tribes using these idioms as their means of intercommunication. Those studied by Dr. Loew are the Mohave, the Hualapai and the Diegeño, and in 1873 he took a vocabulary of the Tonto or Gohun. The other Yuma dialects are the Cocopa, Maricopa, the Cosino, the Yabapai, the Comoyei, and that of the name-giving tribe, the Yuma, who are called Cuchans by their neighbors. The Yuma tribes live on the Gila and Lower Colorado Rivers, and in the Colorado Desert.

THE SANTA BARBARA STOCK.

KASUÁ.

The full extent of the territory in which the idioms of the Santa Barbara family is spoken is unknown to us at present. On the north it is bordered by the idiom spoken at the mission of San Luis Obispo, by that of San Miguel, and probably also by the dialects of the Tatche or Telame Indians, whose intricate grammar and difficult pronunciation has been transmitted to us by the careful notation of Padre B. Sitjar (Vocabulario de la Lengua de los naturales de la Mision de San Antonio, Alta California, in Shea's Linguistics, New York, 1861). To the east and southeast it borders on various Kauvuya idioms to be described below, perhaps also on some Payute dialects; and when following on the map the location of these neighboring idioms, we must conclude that the space allotted to the Santa Barbara family is comparatively narrow.

A vocabulary taken at Santa Barbara by Horatio Hale, of the United States Exploring Expedition, and reprinted in Transact. of Am. Ethnolog. Society, vol. II, page 129, (1848,) does not, though very short and imperfect, differ essentially from Loew's; and we may, therefore, conclude that the Indians seen by Hale virtually spoke a dialect almost identical with that now prevailing among the Kasuá at Cieneguita, 3 miles from Santa Barbara mission. But the dialect observed on Santa Cruz Island by Padre Antonio F. Jimeno, and carefully noted by him on November 4, 1856, shows much difference from that of the mainland; still the great number of roots in which both coincide prove them to be offshoots of substantially the same linguistic family. By a few examples submitted, every reader may be enabled to judge for himself of the differences exhibited by the three vocabularies.

	Kasuá. O. Loew.	*Santa Barbara.* Hale.	*Santa Cruz Island.* Rev. Jimeno.
my forehead	pi khsi		pi gstshe
beard	sats-ůs		tchatses
arrow	yá	yah	yhush
sun	álish	alisháklıua	tannum
moon	ávueigh	aguai	o-uei
night	salkukh	sulkuhu	aughemei
leaf	skáp		hulucappa
water	ó	oh	mihie
meat	sáman		shomun
cold	sakh-tatakh	sokhton	aktaw

The cardinal numerals agree in all three vocabularies, the figures 1 and 5 excepted

A close examination of Loew's *Kasuá* vocabulary, and of the sentences transmitted by him, shows the following phonetic components:

Vowels: u, ů, o, a, ä, e, i.—ů is a surd vowel, equal to u in English *lump*, *thumb*.

Diphthongs: au; ui, oi, ei.

Consonants: k, t, p; g, b, (b very scarce;) kh, gh; s, sh; h, y, (the German jod,) v; n, m; l.

The sounds ts, kh, gh, sh frequently occur, especially at the end of words. d, f, r do not occur at all in the Kasuá dialect, whose words terminate as often in vowels as in consonants, and show a marked tendency to monosyllabism.

On Santa Cruz Island, plurals are mostly formed by reduplication of the first syllable, as in twopau, *bow*, plural two-two-pau, *bows*. In Kasuá we have a few faint indications of a plural being formed by the addition of a syllable: sgut-*et*, *female breasts* gsikhua-e, *nails*, skam, *wings*, compared with skab, *feathers*, but we do not discover at present any plurals or duals formed by reduplication. But still this sort of grammatical synthesis, which occupies such a prominent place in the languages of the Pacific coast, is observed in some Kasuá appellatives which possess a collective meaning: tůptů-ůp, *forest;* shik-shép-shu, *ice;* and in a few verbs, evidently endowed in former times with an iterative signification: pekhpetch, *to sing;* ptiptá-ulgh, *to speak;* ksak-alálan, *to cry;* perhaps also, palpat, *to run*. Verbs frequently commence with a *p*, the transitives as well as the intransitives.

One of the most frequent endings forming substantives is *-sh*; it occurs in knosh, *head*, nokhsh, *nose*, úash, *tobacco-pipe*, and is found in the shape of *-tch* in Santa Cruz Island. Other terminal forms are *-p*, *-gh*, etc., and the two following:

game, *brother*	gamute, *sister*
koko, *father*	khone, *mother*

Most topographical and meteorological terms commence with *s*.

Numerals follow the quinary counting system, and ordinals are formed in the following manner: ishgomo *two*, kumusk *second;* masgh *three*, kamaskh *third.*

Possessive pronouns precede their substantives: uk pu, *my hand;* u pu, *thy* and *his* hand.

In the conjugation of verbs, the negative particle ke, ke-á, precedes the verb; ke tchámon, *I do not know;* the particle of the future tense is shá, and is inserted between the personal pronoun and the verb. The particle of the preterit is double; moe . . . . uash; moe pa shu-un uash, *thou hast eaten.* This *vash* also occurs in the terms for *old;* pagó-uvash; for *morning:* vash-nákhi-et, which also means *to-morrow.*

Our knowledge of the Santa Barbara family of languages has been until now so restricted that the solution of the problem, what linguistic relations it bears to other American languages, could not be attempted with any hope of arriving at the truth. The painstaking labors of O. Loew have now enabled us to investigate this curious idiom more exhaustively, and, as nothing has yet been published concerning it, I intend to expatiate more fully on its affinities. and to draw all the conclusions that can be drawn safely from the material presently available.

The purpose of linguistic comparisons of roots, word-stems, and words belonging to different languages, and showing some similarity in sound and signification, is to find out whether the objects compared are borrowed, or whether they are cognate or not cognate. To do this with safety, the phonetic rules of these languages must have been reduced to a system, and where such systems are yet wanting, as here and in all the Californian languages, only empirical rules can be followed.

The Tatché language of the mission of San Antonio corresponds in the following terms:

	San Antonio.	Kasuá.	Santa Cruz Island.
father	ecco	koko	
chest, breast	tch^e^úuo	ko′-ugh	
blood	akáta	akhóles	aughyoulish
sea	sh′kem	shkámin	
		(Hale: skahanúhui)	
hare	kôl	kú′n	
large, great	kátcha	khá-akh	
small	skitano	tstáne-ugh	
bone	ekhakô		ikukuie
dog	ótcho		wutchu
to drink	kátcheme		tchakmil

The idiom of San Luis Obispo would, if we had a more comprehensive vocabulary of it, show many more affinities than the ones we subjoin here:

	San Luis Obispo.	Kasuá.	Santa Cruz Island.
ear	p'ta	'tu	thú
salt	tepu	tip	
hand	pu	pu	pu, (*plur.* púpu)
man	h'lmono		alamu-un
two	eshin		ishum
three	misha		maseghe

The Mutsun language, spoken in a large tract of territory around San Juan Bautista, does not show any similarities beyond the following:

	Mutsun.	Kasuá.	Santa Cruz Island.
two	utsgin	ishgómo	
nose	us		ishtono

Further to the north, the idiom of the root-digging Wintoons, who live on the upper Sacramento River, corresponds in the following terms:

	Wintoon.	Kasuá.	Santa Cruz Island.
teeth	si	sá	(tcha-) sa
ears	tumut	'tu	

and the Klamath-Modoc in the negative particle *ka*-i, not; Kasuá ke, ke-á; perhaps also in é-ush, *lake;* Kasuá, é-ukeke.

The distant Pima language, spoken on the Gila River and south of it, shows striking analogies in two terms:

mukat, *far off, distant;* Kasuá, mú-ukhk.

ni kuna, n'-kuna, *my husband;* Kasuá, kunivu-e.

It may be reasonably expected that the wide-stretching Shoshonee family, which has even sent a few offshoots down to the barren coast of the southern part of the State of

California, has exercised a powerful influence on the Santa Barbara stock of words. A few may be traced, indeed, to the Kauvuya branch; others seem related to Kiowa and the Pueblos, inasmuch as these two idioms are themselves largely impregnated with Shoshonee words.

Takhtam, tóvuat; Kauvuya, továt, *pine-tree;* Kasuá, tómolgh.

Payute and Chemehuevi, kaiv, *mountain;* Kasuá, khûp, *stone.*

Western Payutes, kauvó, *hair;* Kasuá, okvó-'n.

Kiowa, kóh'-, *mother;* Kasuá, khóne.

Moqui, tsi-i; Tehua, tchi-i, *bird;* Kasuá, tchuivu-e.

Moqui, shuki, *nails;* Kasuá, gsikhua-e.

Moqui, pehue, *to sleep;* Kasuá, pué.

Affinities observed between Kasuá and the neighboring Kizh or Tobikhar will be given below.

Santa Barbara has borrowed from Yuma the term for *chief:* kvátai in Diegeño, (vatéga in Hualapai,) *large, great,* occurs in Santa Cruz Island as ghotah, in San Antonio as kvátai, *chief.*

gámutum, *girls,* in Hualapai, turns up in Kasuá as gamute, *sister.*

A few word roots occur almost in all, or at least in a large number of western languages, with equal or similar signification:

Kasuá, -'tu, *ear;* Wintoon, tumut, (plural:) Kiowa, tá-ati.

Kasuá, ke, ke-a, *not, no;* Kizh, khai, *not;* Payute, gatch; Chemeh. katch.

Kasuá, tip, *salt;* S. L. O., tepe; Maya, táab; occurs in the signification of *rock, stone,* as tipi, timpi, tamp, tu-ump, tub-'e in the Shoshonee dialects.

Kasuá, nó; 'o, J, pron. pers., occurs in western languages as no, noma, nû-û, nû-ni, na, and in many other similar forms.

From Spanish, Kasuá has borrowed the words plata, *silver;* kavay, *horse;* and the use of the article *el,* which is changed into *il.*

From all these word-resemblances and real affinities, no linguist will feel justified to pronounce the Santa Barbara family *cognate* to any of the surrounding idioms, as they are not conclusive enough to prove this. We are sadly in want of the most important criterion for such researches, viz., of reliable grammars and texts; and, while these are wanting, all we can admit is, that the languages in question have simply *borrowed* from each other to a certain extent. There seems to exist, however, a pretty close relation between Kasuá and the neighboring idioms of San Luis Obispo and San Antonio, which deserves to be followed up.

The mission of Santa Barbara was founded on December 4, 1786, and the Indians settled around it were called Silpaleels or Saughpileels, Aswalthatans, &c., all of them using dialects slightly varying from each other. The Indians living around Santa Inez Mission also spoke a dialect of the Santa Barbara family, and their tribes were called Alahulapas, Akachumas, Jonatas, Cascellis, &c. Spanish priests have left us a few liturgic texts of the Santa Barbara as well as of the Santa Inez idioms, and the Lord's prayer is given in Duflot de Mofra's Explorations, vol. II, page 388.

THE SHOSHONEE STOCK.

KAUVUYA.

This is, according to O. Loew, the correct form of the name of the tribe inhabiting the Cabezon or Coahuila Valley, which lies between the San Bernardino range and the San Jacinto Mountains. They are variously called Cawéos, Cavīos, Kavayos, and by Mexicans Coahuila, Cahuillos. Their language, combined with that of the neighboring Takhtam, Serranos or Mountaineers, and the dialects of a few coast tribes, forms the Kauvuya branch of the Shoshonee family of languages.

Vowels: u, o, a, ä, e, i (pronounced as in Italian.)

Diphthongs: au, iu; ui, ai; vowels are *not* nasalized.

Consonants: k, t, p; g, b, (b scarce,) kh; s, sh, h, y, (the German jod,) v; n, m; l. The sounds d, f, r are wanting entirely; kh is the *rough* guttural sound of k in the Spanish *ojo, dejar.*

Combinations of consonants like bs, tch, khk, ksh, are frequently observed.

Kauvuya syllables are generally built up of the combinations: consonant + vowel, or consonant + vowel + consonant.

Syllables made up of one vowel only are not frequent, though the Kauvuyas, as most other Indian tribes, like to drawl out simple vowels by doubling, repeating, or varying them. Thus pem (*these*) becomes pe-em; kil (*not*) ki-il, &c.

Case-inflection is formed here, as elsewhere, by adding to nouns postpositions as suffixes: pal, *water;* pá-aga, *in the water;* tumuet, in Serrano, *mountain;* tamikan, in Kauvuya, *on the mountain.* A possessive case does not appear from the sentences given. The objective or accusative case does not differ from the nominative, but is generally placed after the verb, except in interrogative sentences.

The almost universal termination for the plural of nouns is um, which, in a few instances, diverges into *-ĕm, -im,* (and *-on?*) The ending *-sh* seems to form collective appel-

atives. When assuming the termination of the plural, many nouns insert a new vowel or alter the vowel of the last syllable into a diphthong or another vowel, thus producing a change similar to the *Umlaut* in German, and to the irregular English plurals in goose, *geese;* louse, *lice;* man, *men;* cow, *kine.* We subjoin some instances of Kauvuya plurals:

turtle	ayil	ayilum
fly	a-avat	ava-atum
bird	vigitmol	vigitmoilum
many	mete-uet	mete-etchim
hare	ta'vut	tavutim
boy	tiat	tigitum
fish	ki-ul	kiulĕm

Adjectives assume the plural form as well as substantives do, even when used as predicates or connected with a noun.

Derivatives are formed from roots or stems by the addition of the following terminations:

–at, –it, –ot: sogat, *deer;* alvat, *crow;*
panyit, *egg;* vuyit, *grasshopper;*
huminot, *meat.*
–uet (in Gaitchin, –ut:) pokauet, *snake, lizard;* isuet, *wolf.*
–il: auvil, *blood;* ingil, *salt;* níetchil, *woman;* manyil, *moon.*
–mol: nauishmol, *girl;* tapa-amol, *cup;* nakhánmol, *old.*
–ish: kauvish, *rock, stone.*
–liu: ne gi, *my house;* ne giliu, *my friend.*

In Kauvuya, the numerals strictly follow the quinary counting-system, which they do not in the cognate idioms of the Serranos and Gaitchins.

The terms for parts of the human frame and for consanguinity always prefix the possessive "mine," whose form is determined by the quality of the initial syllable of the following noun, thus appearing under the variable shapes of n'-, na, ne, ni, no, nu.

The interrogative pronoun and particle is *mi–*, as appears from the subjoined list of pronouns and adverbs, to which *mi–* is prefixed:

mi, *what?* hakhe, *who?* mi keats, *how many?* mi pá-akh, *when?* mi vákh, *where?* mi ikhone, *why?* mi vakha, *wherefrom? whence?* mi vikin, *whereto?* mi yákhon, *how?*

From Loew's Kauvuya sentences, I add a few scraps, to the purpose of showing the mode of conjugating verbs:

te, *to see;* men téokve, *I see;* pin téokval, *I have seen you;* pe téokval, *you have seen;* té-e, *look here!* gopka, *to sleep;* hen gopka, *I shall sleep;* hen gopkale, ne gopkalet, *I have slept;* kilia hen gopkale, *I have not slept.*

–al forms verbal adjectives nearly equivalent to our participles in *–ing:* pin ni aukal mukha-a, *I have rheumatism;* literally: "this I having sickness".

pe, pen, pin is prefixed to all transitive or active verbs, and seems to point out a relation of the subject to the outside world; *hen* is prefixed to all intransitive and reflective verbs, and shows a relation of the verb to its subject only, as we observe also in the Greek medium and many Latin deponentia; *hen* may therefore properly be interpreted by *himself, herself, oneself.*

Verbs also assume the plural endings of the nouns: nitchika, *I go;* nitchi-im, *we go.*

Of the Kauvuya dialect, Mr. Loew has transmitted a considerable amount of words and sentences. In taking his notes, he closely followed, in this dialect, as well as in all the others, the graphic method recommended by Turner and Hale, who by their scientific studies were prompted to adopt the Italian pronunciation for most of the letters representing the sounds of their phonetic systems.

TAKHTAM.

This is the general name by which the Indians inhabiting the hills around San Bernardino, Cal., call themselves, and it may be properly used to designate their dialect also. Takhtam simply means *men*, being the plural form of takht, *man.* This word occurs in many Shoshonee languages, and sometimes not only signifies *man*, but also *young man.* The Spanish-speaking population calls the Takhtam *Serranos* or *Mountaineers*, a term frequently used in Mexico to distinguish also dialects of the hill regions from cognate ones of the adjacent plains, and derived from *sierra*, mountain-range.

The Takhtam dialect seems to differ from Kauvuya more in the dictionary than in the grammatical forms. It has the same vowels and does not nasalize them, but as for consonants it differs from it in the following peculiarities:

R occurs in Takhtam as well as in Gaitchin, but less frequently; *f* only in vú-ungaiftch, *rain*, which could be rendered just as well by vú-ungaivtch. I find *d* only in hamd, *grass*, as a terminal sound, and *h* is only found when commencing words. Their *sh* is pronounced down in the throat; the deep guttural *kh* also occurs here. We find

combinations of consonants like *kv, mk, ts, tch, tchk*, occurring more or less frequently. The accent scarcely ever rests on the terminal syllable of a word.

The endings of the plural form of nouns are *–im, –am*, as in Kauvuya, but *–um* does not occur here. Cases are formed by suffixing post-positions to substantives: kitch, *house;* katcháka, *in the house*. Many adjectives are composed with the prefix: akup–, akopo–, kopin–, meaning plurality or abundance, (*much, many.*) Adjectives of colors are formed by means of the suffix –anka, –inka, –inkum, &c. In derivative nouns, the following terminals are most frequently observed; *–tch* being the most common of all, and in fact a substitute for the definite article *the:*

–tch: kitch, *house;* in Kauvuya, gish.
tokuvtch, *sky;* in Kauvuya, tokovas.
á-aetch, *good;* in Kauvuya, átsa-e.
–at: tamyat, *sun;* kotchat, *wood.*
–et: túmuet, *rock;* mó-umet, *sea.*
–it: shuvuit, *wind.*
–ut: honût, *bear;* in Kauvuya, hunuet.

In most verbs, we observe the ending *–kin, –kain*, which corresponds to the *–ka,* and probably also to the *–kal* in Kauvuya verbs, *–al* alternating with *–ain.*

GAITCHIN.

This dialect of the Kauvuya branch of Shoshonee languages is spoken on the coast of the Pacific Ocean at San Juan Capistrano and at San Luis Rey, and, according to Loew's statements, at some distance from the coast at Pala, Temecula and, environs. We possess two old vocabularies taken at San Juan Capistrano from Indians who called themselves *Akátchma,* said to mean "pyramid hill," or "ant hill," and gave to their dialect the appellation of Netela, evidently né täle, no täle, *my speech, my language.*

We have also a few words collected from the San Luiseños Indians, or aborigines settled around San Luis Rey de Francia Mission, which slightly differ from Loew's Gaitchin words, and were said to belong to the *Kechi* language. Gaitchin, Kechi is derived from gitch, kitch *house*, or *settlement*, and consequently identical with "Kizh."

O. Loew obtained his words and sentences from an Indian living near San Juan Capistrano Mission, but hailing from San Luis Rey.

Vowels and diphthongs are the same as in Kauvuya and Takhtam. Of consonants, *d* and *f* do not occur at all, *r* is not found very often and is alternating with *l*; *b* is found only in bi-it, *younger sister.* Words generally show consonantal endings, those in *k, l, t, tch,* being the most common of all.

The accent generally rests on the penultima, though it is often laid on the last syllable of the word-stem, as in magát, *large, great,* vué, *two,* vosá, *four.*

In substantives and adjectives, the plural ends in *–um*, (in San J. Cap. in *–um, –öm, –om, –am,*) and the verb also assumes a plural form, *–otum, –von.*

Adjectives do not drop their plural endings when joined to a noun in the plural.

Nouns are inflected by postpositions in the same manner as in the cognate dialects of the Kauvuya branch: kauitch, *mountain;* kauvi–nga, *in the mountain;* kauvi–ik, *on the mountain;* mout, *sea;* mōm–nga, *in the sea;* pushún–nga, *inside;* pesá–onga, *out doors.*

Further case-inflections appear in the endings *–am* and *–ov* of the following sentences: Gitcham gûmûk, *on the other side of house;* na-á-atch auvólov húikhnunga, *the horse is larger than the dog;* gitch meaning *house,* and aual *dog.*

Terminals for derivative nouns are as follows: –itch (the most frequent): yumi-itch, *forest;* vunú-itch, *river,* &c., and in some adjectives designating colors, in nangvitch, *deaf,* &c.

–al: hungal, *wind;* ékhal, *earth.*
–at: tomat, *lightning.*
–ut: shovó-ut, *winter;* vokhá-ut, *frog.*
–mol, –mul: amayomol, *young;* kavá-amal, *cup;* olú-umul, *small;* titchmol, *butterfly.*
–ant, –ont: vuymkhant, *heavy;* tchórokhont, *round.*
–ev, –ov: emengev, *ripe;* poló-ov, *costly.*

A gradation of the adjective is effected by adding the terms *more* and *very, most;* magát, *great;* magat huikhnunga, *greater;* vam huikhnunga magàt, *greatest,* and in addition to this the gradation is made more apparent by a circumscriptive sentence.

The numerals exhibit elements of the quaternary counting-system, ($2\times2=4$; $4\times2=8$,) the other figures resting on the quinary method of numeration.

The interrogative particle is *mi, me.*

The subject-pronoun is prefixed to the stem of the verb; the negative particle *kai* is inserted before the verb or stands at the head of the sentence.

The particles of the *preterit* tense are: omu . . . gat, or amu . . . gat; those of the *future*: ivi . . . lot, or ati-i . . . let.

more, *to kill:* non amo moregat, *I have killed.*
non ivi morelot, *I shall kill.*
non kai moregat, *I have not killed.*
telévua, *to see:* telévuak, *to see something* (*k* sign of object).
telévtchok, *to talk to somebody,* (viz. to see somebody.)

Father Boscana has left an interesting sketch of the Capistrano Indians, their history, customs, manners, and mythology, in his Chinigchinich, or "World-Maker." Robinson translated it from the Spanish, and published it as an appendix to his "Life in California," 12mo, New York, 1846. The only text of the Gaitchin language given by him is an Indian popular song of five lines, which has been republished in the elaborate treatise of Professor Buschmann, "Traces of the Aztec Language," on page 546. The Lord's Prayer was transmitted by the explorer Duflot de Mofras in 1842 with that of the Kizh.

KIZH.

Of this dialect we possess three vocabularies: that of Dr. Coulter, (1841;) of the Exploring Expedition, collected by H. Hale and published in 1846; and that of Osc. Loew, (1875.) All three were taken at the mission of San Gabriel; but the Lord's Prayer, taken by Mofras, II, 393–4, at San Fernando, proves that various sub-dialects of Kizh are spoken through the whole vicinity of Los Angeles. Neither the term *Kizh* nor *Netela* are known on the spot to designate any particular language or tribe, kizh meaning simply *houses.* The remnants of the once populous tribes or bands settled around San Gabriel Mission call themselves Tobikhars, (meaning *settlers,* from tóba, *to sit,* tobakharó, *to stand* in Kizh) and speak almost universally Spanish. Having adopted the name Gaitchin for the Southern coast dialect, we may just as well use Kizh, which has the same signification of "houses" as a name for the northern twin-idiom.

At first sight, Kizh seems to differ considerably from Gaitchin, Takhtam, and Kauvuya; but a careful comparison of all the vocabularies now available shows that a real affinity exists between the four. The following terms are rendered by the same radical in all the four idioms: father, mother, ear, nose, teeth, arm and hand, heart, arrow, house, heaven, sun, moon, star, water, mountain, bear, fish; I, thou, to drink; one, two, three, four. Kizh agrees at least with two of these dialects in the following important terms: mouth, breast, sea, salt, stone, deer, wolf, fox, rattlesnake, to eat, to kill; and in many of them a close coincidence is observed between Kizh and the Northern Shoshonee dialects on Columbia River and in Montana, the Utah, Payute, Moqui, Comanche, and even the Kiowa. Some words not found in the southern branches occur only in Kizh and the Northern Shoshonee.

It might be with propriety objected to the statement that Kizh is a Shoshonee idiom, the circumstance that the Kizh grammar differs widely from that of the Shoshonee languages; that these latter do not employ reduplication of the first syllable as a means of grammatical synthesis; that they lack the sound *r*, or employ it very rarely; that their possessive pronoun *mine* is *na, ni, nu,* and not *a,* as in Kizh, and that they do not generally place it before the parts of the human body or the degrees of consanguinity.

To these objections we reply as follows: The *a* in Kizh is nothing else but the *na* with apheresis of the initial *n,* and this pronoun sounds *ni* in Kizh before the terms of consanguinity. The northern Shoshonees really *do* prefix the *mine* to the terms of the human limbs and to *father, mother,* &c. The scarcity of the *r* in other idioms proves nothing, since they employ other sounds in its stead, and Kizh lacks *l* almost entirely. Reduplication also occurs in Shoshonee dialects, though not generally to render the idea of plurality as in Kizh. We quote the following instances of reduplication from the Kauvuya branch:

In Kauvuya: yuyuma, *cold;* sasaymol, *duck;* vévonkon, *rain.*

In Takhtam: votchevuetch, *old.*

In Southern Payute: mobits, *fool;* momobits, *fools.*

In Gaitchin: magát, *great,* plural māmt, probably contracted from mamagat.

It is true that the reduplicative plural is a peculiar feature of the languages spoken along the Pacific coast of North America, and it occurs in this quality in Selish, Klamath, Island of Santa Cruz, and probably in many other Californian idioms; also in Pima, Aztec, Tarahumara, and in Tepeguana.

In the elements of verbal inflection, numerals, and in the degrees of consanguinity, Kizh agrees closely with Gaitchin, to which it bears the closest resemblance of all the Kauvuya dialects. But what languages have furnished to Kizh its words not traceable in the other Shoshonee dialects?

Many of them must be, nevertheless, of Shoshonee origin, for we are yet very far from being acquainted with all the Shoshonee words, word-stems, and radicals.

For the others, it may be safely asserted that Kizh did not borrow to any extent from the Yuma family. From the neighboring family of Santa Barbara it probably borrowed the *extensive* use of the reduplicative plural, a grammatical figure not inherent to the Kauvuya family, and an affinity is traceable only in the following words:

	Kizh.	Kasuá.
blood	khain	akhóles
fox	khaúr	khus

San Antonio coincides with Kizh in:

Kizh, voshé, *dog;* S. A., ótcho, ótch; yait, *alive;* S. A., (kakhoo–) yota.

Kizh agrees with other Western idioms in:

uiti, *boy;* Wintoon, uéta, *man;* uéta-ela, *boy.*
tchábo, *fire;* on Sacramento R., ça, sa; Maya, káak.
tam, *teeth;* Pima, tatami.
(pa–) vahe, *six;* Maya, uác, (*seven,* uuc; *eight,* uaxab.)
tota, *stone;* Pima, hotiē, hota; Heve, tet, Azt., tetl.
yu-uit, *great;* Taos, ya-á.

The affinities of Kizh and Gaitchin to Aztec, and to four languages spoken in the northern Mexican provinces, have been pointed out by Prof. J. C. E. Buschmann in a very erudite paper, entitled "Die Sprachen Kizh und Netela." We refer to the words demonstrated by him to be cognate with Aztec, and only present the subsequent ones

Kizh.	Aztec.
otsó-o, *cold*	ytztic, (Shosh., utshuin)
mahar, *five*	macuilli
mukánakh, *to kill*	macmiqui
pukitcha, *to steal*	itchtequi
(pau–) enatch, *to cry*	(t–) enotza

Buschmann seems willing to admit that the noun-endings *–t, –ta, –te, –ti, –ts, –tch,* in Kizh, replace or closely correspond to the Aztec terminals *–tl, –tli,* and shows four ways of forming plurals in Kizh:

(1) by reduplicating the initial syllable, as in haikh, *mountain,* pl. hahaikh; tchinuit *small,* pl. tchitchinui; (2) by syncope; (3) by affixing –nöt, –röt; and (4) by affixing the Gaitchin terminal *–om, –öm.*

Ordinals differ somewhat from cardinals.

The particle of the future tense *–on* is suffixed to the verb; that of the preterit, *yamo–,* prefixed to it.

The language of this tribe does not sound unharmoniously to the ear, and shows a vigorous, energetic constitution in its words and sentences.

PAYUTE BRANCH.

Passing from the Kauvuya branch to the Payute branch of Shoshonee languages, we are struck, when first glancing over Loew's very complete vocabularies, with the preponderance of deep-sounding vowels, as *o, u,* and *a,* over the high-pitched *e, i*; and *o, u,* often assume a darker shade by being pronounced surd, (ů, o,) or by being nasalized, (ã, õ, ũ, ů.) This pronunciation of the three vowels is also peculiar to the Utah, and occurs in many of the Pueblo idioms of New Mexico. In addition to this, we perceive in the Payute dialects a frequent occurrence of a vocalic *r*, marked r̨, and in the dialect of Mono and Inyo Counties, Cal., a buzzing *s*, marked *s̨*.

The three dialects studied by Loew almost entirely lack the sounds of *d* and *f*; *b* and *v* occur frequently in word-terminals, and there seem to be interchangeable.

Payute is evidently a sister language of Utah, and bears close relationship to it. It extends over the whole of Nevada and parts of the adjacent States and Territories.

O. Loew has taken words and sentences of the Southern Payutes on the Colorado River, of the Chemehuevis settled on a reserve on the western shore of Colorado River, and of the Western Payutes roaming in Mono and Inyo Counties, California.

Although these three do not differ widely among themselves, greater discrepancies will be probably observed between these Southern and the *Northern* dialects of Nevada, when we will be in possession of linguistic materials from these parts.

In order to exhibit more plainly the dialectic differences between the Southern and Western Payute, the Chemehuevi, and the Uintah-Utah, I subjoin a comparative table of words.

	Southern Payute.	Chemehuevi.	Western Payute.	Uintah-Utah.
body	né-uav	nó-uan	nu-um	ningovh
teeth	távuamb	tauvamb	tava	taua
hand	mo-om	mu-um	vu-ēla	mů
bone	a-óv	ó-oan	oho	
bow	atch	atch	éde	á-ats
snow	ne-ovav	novab	nevave	nevavai
fire	kun	ku-un, kun	kosh	k'-un
rock, stone,	tůmp	tu-ump, tump	túbé'e	timb
fly	mubitch	mobitch	m-úivi	múpu
who?	hangi	hangá	hagé	hang
yes!	ẽ-ẽ	ů-ũ	hũ-ũ	ũ-vay
no!	gatch	katch	karú-u	kats
to eat	tokai	tokara	tůgate	teke

For want of space, I have to refrain from extending this table over all the other Shoshonee languages and dialects. To do this would certainly be very instructive and also furnish materials from which to derive phonetic laws for the whole Shoshonee family.

SOUTHERN PAYUTES.

The words and sentences given by O. Loew were gathered from Indians living at the little mining town of Yvanpah, west of Colorado River, Nevada, compared in Cottonwood Island and at Stone's Ferry, both settlements being located on Colorado River. Some more words were added on the last-mentioned place.

Vowels: u, ũ, o, a, e, i.

Nasalized vowels: ã, ẽ, õ, ũ.

Diphthongs: au; i, ei, ui.

Consonants: k, t, p; g, d, (occurs only in pa-ubd, *blood*,) b; kh; s, sh; h, y, (the German j,) v; ng, n, m; r, ṛ. l and f do not occur.

In words having no derivative ending, the accent mostly rests on the penultima; and, in words provided with such a termination, it commonly rests on the syllable preceding it.

In this idiom, as in Kizh, we notice several modes of forming the plural of nouns, and singularly enough even cardinal numbers show a singular and a plural form.

This curious circumstance might be explained through the law of analogy; but probably the plural of the numeral has here a distributive meaning, like *quini*, *deni*, in Latin.

Plurals in –atum: avan, *many*, *much*, avá –atum.
in –im, –am: pa-átsiv, *louse*, pa-átsivim; hun, *rat*, hunam.
in –vun, –um: tukibun, *friend*; tukibuvun, pay-ay, *three*, pa-ayum.
in –uts: narávungg, *sheep*, narávunguts.
in –aṛa: hivinump, *cup*, hivinumpaṛa; sovib, *cottonwood-tree*, sovíbaṛa.

All these various endings can be easily reduced to three original forms: *–atum*, (or *–itum*); *–uts* (or *–its*); *–aṛa*.

The first of them changes into *–itum*, *–otum*, etc., the penultima being always short and indistinctly uttered; or it collapses, by dropping the *–at*, *–it*, into *–am*, *–im*, *–om*, *–un*, etc. The second terminal, *–uts*, probably corresponds to the collective *–tch* in Kizh and Gaitchin; the third, *–aṛa*, evidently is the adjective avan, *many*, *much*, having altered its pronunciation into *ava*, *aua*, *aṛa*.

When adjectives and numerals are joined to substantives expressing inanimate objects, they are liable to drop their plural endings. No separate form exists for ordinal numbers.

The most frequent derivative termination in nouns is: *–ab*, probably equivalent to *–ob* and *–ub*; pa-uyab, *mud*; kanab, *large willow*; movitob, *narines*; angási –urub, *leather strap*. Other endings are:

–ib, –iv: anókuib, *a kind of squash*; pigiv, *bread*.
–av: haiko-ótsav, *bottle*, and in many parts of the human frame.
–at: móbuat, *fool*.
–an: puṛuan, *skin*; vuytsan, *calf of leg*.
–ash, –ats, –atch: shuyush, *one*; tauats, *man*; na-ůbitch, *wet*.
–ump: aṛump, *tongue*; po-onump, *lead-pencil*.

In nouns, a case-inflection is observed as in the Kauvuya dialects: p'-a, *water*; pa-upa, *in the water*; kaiv, *mountain*; kaiv-umbay, *on the mountain*.

The subject-pronoun prefixed to the verb is frequently omitted when there is no doubt of the meaning of the sentence.

Negative sentences begin with the negative particle, and positive (not interrogative) sentences generally with the predicate, and when the subject is not expressed, with the object: pa-ai avan hiviga, *I have drunk much water*.

Tenses are formed after the following model: nuni tokay, *I eat*; nuni tokayan, *I have eaten*; katchun tokayan, *I have not eaten*; nuni tekavan, *I shall eat*; katchun teka-vau-va, *I shall not eat*.

CHEMEHUEVI.

This Payute sub-dialect does not differ half as much from the Southern Payute than Spanish does from Portuguese, and many of the differences observed in Loew's vocabularies between the two seem to depend only on the individual pronunciation of the Indians from whom he obtained his information. Chemehuevi has frequently *p* and *tch*, where S. P. has *b* and *ts*. Like the Southern Payutes, the Chemehuevis do not prefix the possessive *mine* to the degrees of consanguinity and the parts of the human body as the Western Payutes do, who abbreviate the *ni* into *i*.

The terms for numerals, colors, man's limbs, and in fact the great majority of all the terms noted by Loew, radically agree in both dialects, and from this we can infer that their grammatical structure may be of the same type also, though no sentences of the Chemehuevi are at present submitted for examination.

WESTERN PAYUTES.

The dialect spoken in the extensive mountain-tracts of Mono and Inyo Counties, California, and some adjacent parts of Nevada, diverges considerably from the Southern Payute, and seems to have retained many terms in common with the neighboring idiom of the Western Shoshonees or Snake Indians. The personal appearance of the Western Payutes, especially their features, vividly recall to our mind the Mongolian type of mankind. Their deportment does not offend our ideas of propriety, and their faces bear a friendly, often intelligent, expression. Some of the aborigines are earning wages from American settlers, but the majority lead a wretched life by feeding on pine-nuts, roots, worms, and lizards.

Mr. Loew collected the main part of his linguistic material in Benton, Mono County. The sentences and a few terms were taken in Aurora, a little mining town of Inyo County, on the borders of California and Nevada. A few dialectic variations can be traced between the idioms of both places.

Vowels: u, ů, o, a, e, i.

Nasalized vowels: ã, ẽ, ũ.

Diphthongs: au; ai, oi, ui.

Consonants: k, t, p; g, b; s, ş, (or ss,) sh; h, y, (the German j,) v; n, m; r, ŗ.

Western Payute, therefore, lacks the consonantal sounds of *f*, *th*, (which occurs in Mohave,) *kh*, *l*; and *d* may be said to be wanting also, for it occurs only in éde, *bow*.

Syllables generally begin with consonants, but terminate as often in vowels as in consonants. *v* seems to alternate with *b* and *p* and *ts*, *tch* of the southern dialects often turns up as *r* in Western Payute.

Of derivative endings of nouns, the most frequent is –*ve*, as in Zuñi: toyáve, *mountain*; ováve, *salt*; vóve, *wood*. Other terminations are:

–ut: nugut, *goose*; tuná-agut, *great spirit*.

–ib: tuvib, *sand*; toshumíb, *midnight*.

–sh: agásh, *feathers*; agish, *grasshopper*.

Western Payute must have dropped long ago the plural ending observed in almost all the Shoshonee languages, (–*um* or –*im*, –*ăm*;) pagve, *fish*; vahai pagve, *two fish*. In a few words, however, we notice that plural forms have been retained, as in num, *man*; plural, ná-ana; and the ending –*im*, –*itim* re-appears in the plural forms of verbs, as in koinú-itim, *to hunt*—said of many persons hunting, or of many animals hunted.

The names for the colors end in –nagite, except that of *yellow*, which exhibits the contracted form oahanite.

The interrogative pronouns and particles are as follows:

hayó-o, *what?*

hino-oy, hino-oytu: *how many?*

hanágue, *whence! wherefrom?* hinó-ue, *when?* o-u hŭ-ut, *whereto?*

Tenses and negative sentences are formed in this manner:

To drink, hivít: *I shall drink*, hiví nũ.
I have drunk, hivívai nũ.
I have not drunk, garo-o nũ hiví.

To sleep, ůvuit: *I have slept*, (already,) nũ vi tushu hapíyu.
I shall sleep, mi-asha haví.

Many transitive and intransitive verbs end in –at (or –it, –ut): yaróhat, *to speak, talk*, in the Aurora subdialect: yarú-a; navágiat, *to swim*; kvatohat, *to fall*; voagit, *to work*; húvi- -erut, *to sing*; in the Benton subdialect the majority of all verbs seems to have this termination, which in the plural form is increased by –*im*. From the lengthy trisyllabic or quadrisyllabic forms of most verbs we may readily infer that they are compounds of the root, with some pronominal affixes, nouns or fragments of nouns.

THE YUMA STOCK.

Owing to the patient labors of Dr. Loew, the Yuma group in its totality of dialects will become one of the best known of all the language-families of Western North America when the collections of words and sentences made by him will be made

public. Loew has studied four of its dialects, while before him only the Mohave and the Yuma proper, (or Yuma-Cuchan, as I call it,) were known to a certain extent, and a few vocables only had been published of the Diegeño (Comoyei) and Maricopa. (See Reports on Pacific Railroad, vol. III.)

The dialects which constitute the Yuma family of languages are spoken east and west of the Lower Colorado and on Gila River. The Yuma family has kept itself pretty independent from extraneous influence, for it did adopt only a very few terms, if any, from the neighboring Santa Barbara, Kauvuya, Payute, Pueblo, Apache, Pima, from Opata, and other Sonora dialects.

Owing to the prevalence of the vocalic element, Yuma is sonorous and not unpleasant to ears unaccustomed to aboriginal speech. Though words often end in consonants, vocalic terminations prevail in initial syllables and in syllables of the middle part of the word. The elements of which Yuma syllables are mainly made up are a consonant followed by a vowel. The counting system is the quinary one, and the numbers from *six* to *ten* disagree considerably in the different dialects.

The words of the six dialects of which we have the vocabularies illustrate and explain each other mutually, and many forms can be truly understood only by referring to a parallel from another dialect. To show their phonetic differences, the best means will be to quote some terms coinciding in their radicals.

	Mohave.	Hualapai.	Diegeño.	Cuchan.	Tonto.	Maricopa.
nose	ihu	yaiya	khu	ihós	hu	yehe-utche
beard	yavume	yavenime-e	alemé	yabo-íue	yanimi	yebomits
hand		sal	i-salgh	i-sāltche	shála	
arrow	ipá	apá-a	bal	n'yepá	apa	
knife	akhkvue	kva-a	akhgoá		akvá	
sun	anyá	inyá-a	inyá	n'yatch	nyã	n'yats
fire	á-aua	tuga	á-ua	aa-wó	ho-o	áhutch
water	akha	ahá-a	akhá	ahá	aha	
earth	amata	mat	mat	omút	mata	
stone	aví	uvi	ú-uil	oví	vui	
black	vanilgh	niágh	nilgh	n'yulk	nya	
large	vatá-im	vatéga	kvatai	otaike	vete	betátchi
I	inie-pa	anyá-a	inyau	n'yat	'nya-a	inyáts
two	havik	hovak	óak	havik	uake	
to drink	akhathim	akhathiga	kisi	hasúe	hasi	

We now turn our attention to the Mohave dialect, of which about 120 sentences and over 400 words were transmitted by Dr. O. Loew.

MOHAVE.

The individuals using this dialect are at present located upon two reservations. About 1,540 Mohaves, 600 Hualapais, 540 Chemehuevis, 180 Cocopas, and as many Kauvuyas are tilling the ground in the Colorado River agency on the eastern shore of the river; and about 400 Mojaves were removed in 1875, with 678 Tontos and 500 Cuchans from Camp Verde to the White Mountain reserve on the Gila River. They are a peaceably disposed, laborious set of Indians, who seem to have forgotten the fierce wars formerly waged by them against their aggressive neighbors. They tattoo the whole of their body in various colors. Their name is also written Mahhaos, Mo-óav, in Spanish Mojaves.

They do not nasalize or alter their *vowels*, which are to the number of five, *u*, *o*, *a*, *e*, *i*, and five diphthongs: *au*; *ai*, *ei*, *ui*, *oi*. They possess all our *consonants* except *f*, and though they have a very complete series of them, they rarely double them. The series is as follows:

	Not aspirated.	Aspirated.	Spirants.	Nasals.	*R* and *l* sounds.
Gutturals:	k, g	kh, gh	h	ng	
Palatals:	tch		ç, y		
Linguals:			sh		r, r̤, l
Dentals:	t, d	th	s	n	
Labials:	p, b		v	m	

Heterogeneous vowels often meet, and produce hiatus: á-uva, *tobacco*; kahu-eilk, etc *r* and *d* seldom occur. No other consonants can end a word but the following: *-g*, *-gh* *-k*, *-l*, *-m*, *-n*, *-p*.

We find in this dialect the following combinations of consonants: *bk*, *lk*, *tk*, *thk*, *mk*, *rk*, *vk*, *lg*, *shg*, *thp*, *gv*, *nqv*, *ngb*, *mb*, all of which are of easy pronunciation.

The accent generally rests on the final syllable of the word-stem; inflective termin-

ations usually are not accentuated. In many terms, the accentuation is dubious, but generally rests on the same syllable through all the dialects.

Of derivative endings, the most frequent for substantives is *–a*, preceded by a consonant, (*–ta*, *–ya* etc.;) for instance, vu-úga, *thunder;* asha, *bird;* vayaniya, *wine;* avuyá, *door;* amata, *earth;* huksara, *wolf.* –k is also very frequent.

–ik, *–lk* very frequently terminate adjectives; as, tauvanik, *low;* hibilk, *hot;* nakvimulk, *rich.* Another termination is *–um*, which occurs very often: ara-árum, *deep;* akú-utchum, *ripe.*

Substantives do not assume any sign of the plural, and it is doubtful whether adjectives and pronouns do; as, inyep ido namasávum, *my teeth are white;* makatitum, *who, which* (pl.); ataik, *much*, (sing.); ataim, *many* (plur.) shows a form probably contracted from ataikum. Adjectives and numerals are placed after the noun which they qualify.

A gradation of the adjective is effected by a circumscriptive sentence or by the particles *táhana*, *nimka-amk*, more; the superlative repeats the *táhana* or *tahán* twice or three times.

In regard to case-inflection, no distinct mark exists for the possessive and dative case except the position of the words. The accusative is rendered by prefixing *–entch* to the direct object of the sentence, and by placing this object between the subject of the sentence and the transitive verb. Relations expressed by our prepositions are rendered by postpositions: ava iiuvá-aga, *in the house;* avá matarelgh, *outside of the house.*

The pronoun entch, intch, abbreviated itchi, tchi,–tch, is a demonstrative, and in compound nouns and verbs means *somebody* or *somewhat, something.* Substantives composed with it are itchi-halyúluve, *stove, oven*, (viz. *something-smoking;*) itch-anyo-ora-ahaga, *inkstand*, (viz. somewhat-writing-liquid;) Verbs: tcha-koark, *to speak*, verbally "something-say;" tchi-kiauk, *to bite*, verbally "something bite." This element is one of the most frequently occurring parts of Mohave speech, and also serves to form accusatives, as mentioned above, and in this quality means *him, her, it, them.* As the definite *article* it is frequently suffixed to nouns, as in ipá, *man;* ipátch, *certain man just spoken of;* gutch, *what?* contracted from ka-entch, literally, what-thing, or what-it?

There are three other demonstrative pronouns which are used in similar combinations: *ti*, *inya*, and *pa.*

Personal object-pronouns are suffixed to the verb; subject-pronouns are frequently omitted when there is no doubt about the meaning of the sentence.

The elements of verbal inflection are as follows:

Iyéma, *I go;* match'm iyema, *thou goest;* hovatch iyema, *he goes;* inyetch iyema, *we go;* match'm iyema má-ama, *you go;* tcha-am't iyema, *they go;* iyema, *I will go;* iyema tétchuma, *I have gone;* iye-em potchuma, *I did go;* iyemota, *I do not go;* iyemotum tétchuma (or: iye-em mo-ot e-ep tétchuma) or iyemotum pótchuma, *I have not gone.*

The negative particle *mot* is incorporated into the verb, and also serves as privative particle in the derivation of adjectives: ithperum, *strong;* hithpermutum, *weak;* tétchuma and pótchuma are composed of three pronominal roots: ti, entch, ma; pa, entch, ma, and are intended to mark a past tense more or less remote.

Concerning the modes in which verbs are composed in Mohave, we frequently find a syllable *hi–*, prefixed to the stem of reflective and intransitive verbs, as hilgivak, *to ride;* hitchibsk, *to fall*, etc. This particle seems to form verbs equivalent to the medio-passive verbs in Greek.

Of the verbal terminations, *–um* is the most frequent, and occurs in tapuyum, *to kill;* tchegovárum, *to laugh;* kotá-akum, *to open* (a door;) besides this we find a large number of verbs ending in *–k*, or more explicitly in *–ák*, (akhoák, *to smoke*,)*–ók* (hiók, *to vomit*,) *–isk*, *–ilk*, *–eilk*, etc., which often have the accent on the last syllable.

A large number of verbs is formed directly from nouns, for instance:

mata, *earth;* matahúilk, *to dig a hole.*

oyá *air, breath;* tchoho-ik, *to whistle, blow.*

agóaga, *deer;* gógo, *fox;* ha-ilguág, *to hunt.*

To show more clearly the mode of word-composition in Mohave, I add a few groups of words centering around one root and arranged etymologically.

AHAT, HATA, ANIMAL, BEAST: ahát, ahat-o-ólove, *horse;* hata-ghlal, *saddle;* hati-ánik, *bit of horse;* ahat-kagham, *spur;* hatchóra, akhatchóra, *dog;* makho-háta, *bear*-amo-nio-hat, *domestic, tame sheep;* maguá-kuiniu-hata, *hog;* in Hualapai akhániga, *alive.*

MATA, AMATA, EARTH, GROUND: amata-tchikvara (in Diegeño), *meadow, prairie;* maták (Mohave), *north;* matagó-opa, *hole;* matahúilk, *to dig a hole;* mathé, *mud;* matara, *outside;* matana, *inside;* matuma, *inwardly;* matmaguilya, *skin* (as the enclosing substance).

IL, THREAD, in Diegeño, *wood;* ivu-il, *grass*, in Hualapai, vila in Tonto; ilvi, *green, light green;* avo-ilpo, *pole, stick;* si-vilya, *feathers;* ilya, final syllable in tree names.

AKHA, WATER: aha-tchopa, *well, water, pump;* akhathim, athim, *to drink, to drink water;* akh-mata, *squash, pumpkin;* akh-ké-el, opposite (viz. beyond the water); aháyam, *wet;* kható, *island;* nu-há-vuk, *cloud.*

HUALAPAI.

This dialect is closely related to Mohave, since the tribe of the Wallpais, Wallapais, or, according to Spanish orthography, Hualapais, have constantly lived in close contiguity and intercourse with the Mohaves. In the spring of 1874, 580 Hualapais came to the Colorado River reservation, where they live together with about 1,540 Mohaves and many other Indians.

The lexicon of this dialect shows many terms in which it differs from Mohave and the other dialects. But the prefixes, suffixes, derivative endings, &c., are substantially the same, showing many dialectic variations, however. So we observe that the Hualapai terminal -aga is in Mohave -aga; -ega becomes -á or -um; -oga turns up as -auk, u-uga as -ug; koark, *to speak*, appears as koaúk in Hualapai; harabk as hatabuk, *five*; mailhó as malú-u, *tobacco-pipe*. In a good number of terms, H. coincides entirely with Tonto, or more closely than with Mohave.

Being in want of the material requisite to construct a complete grammar of this Yuma dialect, hitherto almost unknown, I subjoin the few sentences given by Dr. Loew illustrating the inflection of the verb, in which the auxiliary verb *I go*, miama, is used to designate the future tense.

kvimago, *I eat.*
miama kvimago, *I shall eat*, (viz, "I go eat.")
kvimago vam, *I have eaten just now.*
kvimago kuré, *I have eaten some time ago.*
kvimago ta ópaka, *I will not eat.*
kutchu kanaba, *What do you want?*

vam in Hual. means *now, to-day*, and kuré occurs in Diegeño as okur: *distant, far off*. The negative particle ta is found also in tuya, *nothing*.

DIEGEÑO.

The Indians of the Yuma stock belonging to this warlike race were called so from the vicinity of the seaport San Diego, in Southern California, which will be the terminus of the Southern Pacific Railroad. The correct form for this name would be Diegueños, or San Diegunos, but Diegeños is now generally adopted. Some travelers have asserted that the Diegeños were identical with the Comoyei, or Comoyas, inhabiting some desert plains between that port and the mouth of the Colorado River, but the words taken from both prove that in their language, at least, some difference exists.

Diegeño and Cuchan exhibit many radical discrepancies in the vocabulary, and it is not improbable that the languages of the Californian peninsula have in former times influenced their stock of words; and a few expressions are traceable to Sonora sources.

Diegeño words more frequently end in consonants than those of Tonto, Mohave, and Hualapai, but the consonantal combinations and the grouping of the sounds are substantially the same as in Mohave. The gutturals *gh* and *kh* occur very frequently, but *th* of the Mohave, which is pronounced just like the English *th*, is not found. Among two hundred terms I find *r* occurring only in three, viz, sepir, *strong;* kitchur, *cold, winter;* okur, *distant.*

The accent not unfrequently rests on the final syllable of nouns as well as of verbs.

The parts of the human body assume the prefixed pronoun -*i*,("mine"), but nothing of the kind is observed in the degrees of consanguinity.

Of compound nouns we notice: akhá-kvan, *river*, viz. "*large-water;*" uma-teté, *mountain*, viz. "rock- above;" amata-tchikvara, *meadow, prairie*, viz. "ground-which-large;" khá-silgh, *sea*, viz. "water-salt."

Numerals from six to nine are composed with nio-, niu-, and Loew's numbers differ largely from those given by Whipple in the reports. These latter were probably taken from a Comoyei Indian.

No sentences or conjugations are at present available from which to construct paradigms or syntactic rules for the Diegeño dialect, and from all what may be inferred from the vocabularies, it must differ in this respect considerably from the Mohave and from Yuma-Cuchan, of which Lieutenant Whipple has given us some phraseology.

Undoubtedly the several Yuma dialects have borrowed a few words from nations speaking various other languages, as it is observed all over America, but in general this family kept itself more free from such importations than many other Indian races. A faint relationship, not heretofore mentioned by any investigator, exists between Yuma and the dialects of the peninsula of California. This connection deserves to be followed up as closely as the scanty material which we possess of the peninsular idioms will allow, and in this way an ancient immigration of some Yuma tribes into this deserted and barren stretch of land may be traced out and proved by linguistic research. I will here only point out the following similarities:

Cochimí: amat, amet, ammet, *earth;* Mohave: amat; Cuchan, omút.

Cochimí: ama, amma, ambayujúp; Waikuru: datembá, *heaven, sky.* Mohave: amaya; Cuchan, ammai.

Cochimí: maba, *upon, above.* Mohave: amail, *above.*

Laymonic: litsi, *to drink;* Diegeño, kisi; Cuchan: asi.

I conclude this brief notice on the eleven idioms studied in 1875 by Dr. Oscar Loew with the remark that, when his collections of words and sentences shall have appeared in print, careful comparative studies of their contents will undoubtedly throw more light on the origin and peculiarities of these languages than I have been able to give within the short space allotted to me in these pages. From other travelers or from residents on the Colorado River and its tributaries we may soon expect further contributions to the linguistic information gathered up to this day among the interesting tribes settled there. Then a new era will dawn upon the elucidation of the linguistic treasures still hidden near the lofty cañons of that majestic western stream.

APPENDIX KK.

STATEMENT OF INSTRUMENTS RECEIVED AND ISSUED BY MAJOR HENRY L. ABBOT, CORPS OF ENGINEERS, FROM THE ENGINEER DEPOT, WILLET'S POINT, N. Y., FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

ENGINEER DEPOT,
Willet's Point, New York Harbor, October 16, 1876.

GENERAL: I have the honor to inclose herewith a return of instruments received at and issued from the engineer depot during the last fiscal year.

Very respectfully, your obedient servant,

HENRY L. ABBOT,
Major of Engineers, Commanding.

Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Names.	Number received.	Number issued.
Astronomical transits	1	....
Chronometers	1	....
Sextants	6	2
Artificial horizons	7	....
Reflecting circles	1	1
Barometers, mercurial cistern	10	1
Barometers, aneroid	20	....
Psychrometers	1	1
Thermometers, maximum	2	1
Thermometers, minimum	2	1
Theodolites, 9″	1	....
Theodolites, 6″	7	....
Astronomical transit and zenith telescope combined	1	....
Transits, railroad	12	5
Compasses, surveyors'	5	....
Gradienters	....	1
Levels, surveyors'	10	5
Level targets	4	2
Chains, 100 feet	10	2
Chains, 66 feet	....	2
Chains, 50 feet	10	....
Pins	....	2 sets.
Steel tapes	5	....
Metallic tapes	....	1
Linen tapes, 100 feet	10	2
Linen tapes, 50 feet	10	....
Binocular field-glasses	1	2
Odometers	65	13
Prismatic compasses	57	6
Pocket sextants	....	2
Compasses, pocket square	....	10
Hand-levels, reflecting	....	5
Watches	....	3
Protractors, Abbot's	....	10
Drawing-instruments	....	2 boxes.
Wooden rulers	....	4
Parallel rulers	1	1
Irregular curves	....	1
Total	260	88
Self-registering tide-gauge paper	....	½ roll.

APPENDIX LL.

ANNUAL REPORT OF COLONEL O. M. POE, AID-DE-CAMP AND MAJOR OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

ENGINEER OFFICE,
HEADQUARTERS ARMY OF THE UNITED STATES,
Washington, D. C., October 20, 1876.

SIR: Owing principally to the fact that since the 1st of July, 1875, I have not had in my charge any public funds applicable to expenses of the fiscal year ending June 30, 1876, I have but little to report in connection with surveys for military defenses, or surveys and reconnaissances in military divisions and departments.

The operations of the several engineer officers on duty at military division and department headquarters are reported by them directly to the Chief of Engineers.

During the year I have exercised personal supervision over the compilation of the map of the Department of Texas, scale 1 inch to 8 miles, and good progress has been made upon it. All the data in the office of the Chief of Engineers, or obtainable elsewhere, applicable to the purpose has been made use of, and to the extent to which it has progressed the result is a better map of the region than any heretofore compiled.

I have also exercised a general supervision over the compilation in the office of the Chief of Engineers of the maps intended to illustrate the Atlantic campaign. Of these, sheets Nos. I and III had been completed at the end of the fiscal year, and the one illustrating the siege of Atlanta nearly so. The last includes the result of special surveys of the battle-field of the 22d July, 1864, made by me in November, 1875. Good progress was also made upon sheets Nos. II and V.

During the year every requisition upon me for ordinary reconnoitering instruments was duly honored. The following table shows the number issued and to whom:

Military division or department.	Prismatic compasses.	Odometers.	Drawing-instruments.
Department of the Platte	6	7	1
Wheeler's explorations	....	24	11
Military Division of the Pacific	....	5	....
Total	6	36	12

Leaving on hand and subject to requisition: 43 prismatic compasses, 17 odometers, 24 sets drawing-instruments.

I am, sir, very respectfully, your obedient servant,

O. M. POE,
Major of Engineers, &c., Col., A. D. C.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

APPENDIX M M.

ANNUAL REPORT OF MAJOR G. L. GILLESPIE, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

EXPLORATIONS AND SURVEYS, MILITARY DIVISION OF THE MISSOURI.

HEADQUARTERS MILITARY DIVISION OF THE MISSOURI,
OFFICE OF THE CHIEF ENGINEER,
Chicago, Ill., July 11, 1876.

GENERAL: I have the honor to submit my annual report of operations as engineer officer at headquarters Military Division of the Missouri, for the fiscal year ending June 30, 1876.

The limited number of reliable itineraries of scouts received during the year at this office from the department engineers has not permitted any great or specially important changes to be made in existing maps of the Western Territories. Those that have reached me direct, as well as those accompanying reports to the adjutant-general of the division, and referred to me, have been carefully reduced, and when deemed reliable the information and changes contained therein have been added to the progress map of the division. Sheets Nos. 2 and 3 of map of Western Territories, under preparation in this office, have been completed. The latter was photo-lithographed in the office of the Chief of Engineers, January, 1876, and issued to the troops in the field in view of expected Indian operations in the Black Hills, and in the country adjacent, to the north and northwest, along the Yellowstone River and its principal tributaries, the Powder, Tongue, and the Big Horn. The former, which includes Texas, has been engraved on copper-plate in this office by Morton Collins, private Company B, Twenty-third Infantry, and is now ready to be printed. A proof-copy will accompany this report.

The engravings upon copper-plates, also executed by Private Collins, of the military reservations and plans of the military posts in the Mililtary Division of the Missouri, mentioned in last annual report, have albeen completed and one hundred copies of each printed. These reser, vations and plans of posts, together with a small map of the division have been bound in the second edition of the book of "Outline Description of the Military Posts in the Military Division of the Missouri," which has been revised and corrected to date in this office, and to which some important information relative to Indian treaties and armaments of the posts has been added.

But little progress has been made in the preparation of sheet No. 4 of the Western Territories, as the manifold duties of the office have engrossed all the time of the one draughtsman allowed me.

A great deal of time is taken up in making tracings of sketches and maps accompanying reports passing through these headquarters, which tracings are required to perfect the files of reports kept in the office of the Adjutant-General.

The various duties of the year may be enumerated under the following heads:

1. Finished sheets 2 and 3 of map of Western Territories, scale 1–2,000,000. Sheet No. 4 of the same map in course of preparation, for which reductions have been made from Lieutenant Wheeler's sheets 50,

59, and 67; from Lieutenant Ruffner's map of New Mexico; from the Land-Office surveys in Colorado, and from various special surveys.

2. Revised and corrected Captain Raynolds's map 1859–'60 of the Yellowstone and Missouri Rivers.

3. Made additions and corrections on the map of Kansas, Texas, and Indian Territory, including operations of Colonel Mackenzie and Lieutenant-Colonel Shafter. Copy accompanies this report.

4. Revised and corrected "Outline Description of the Posts in the Military Division of the Missouri," and prepared maps for the same.

5. Made duplicate tracings of the following reservations and plans of posts: Camp Robinson, Nebraska; Camp Sheridan, Nebraska; Sidney Barracks, Nebraska; Fort Hartsuff, Nebraska; Cheyenne Agency, Dakota; San Antonio, Tex.; Camp Douglas, Utah; Cantonment on the Sweetwater, Texas, and Fort Union, New Mexico.

6. Made duplicate tracings for the adjutant-general of the division of all sketches and maps accompanying reports referring to Indian operations.

7. Completed the engraving of sheet No. 2 of map of Western Territories, and that of the residue of the plans of posts and military reservations required to complete the book of "Outline Description," &c., mentioned under heading No. 4.

8. Compiled and arranged for the office files of this office every information that could be obtained relative to the date of declaration, the extent and establishment of the several military posts and reservations in the Military Division of the Missouri.

I accompany this report with a map showing to date the lines of march of the several columns of troops in the field operating against the hostile Sioux Indians, under command of Brig. Gen. A. H. Terry, U. S. A., Brig. Gen. George Crook, U. S. A., Col. John Gibbon, Seventh United States Infantry, and Col. Wesley Merritt, Fifth United States Cavalry.*

The first campaign, led by Brigadier-General Crook, and which had for its object the destruction of that band of the Sioux under a chief named Crazy Horse, left Fort Fetterman March 1, 1876. The column followed the old Phil. Kearney road to the Powder River at Fort Reno, thence moved direct to the headwaters of Tongue River, thence down the valley of the Tongue River to Red Clay, and thence by the valley of Otter Creek across to the Powder River, a short distance west of the forks, where a battle was fought March 17, resulting in the destruction of the village of Crazy Horse. Returning, the command reached Fort Fetterman March 26, 1876.

March 17, 1876, Colonel Gibbon left Fort Shaw for the Yellowstone River to take part in a general campaign against the Sioux, in connection with the column under General Crook from Fort Fetterman and with the column from Fort Lincoln under General Terry. The initial points of starting of these columns being so widely separated, no detailed plan of operation not subject to change could be adopted, but the movements of each were so ordered as to prevent primarily the Indians passing north of the Yellowstone, and it was designed and expected to confine the campaign to the country immediately adjacent to the Big Horn Mountains, or along the valleys of the rivers which have their sources in these mountains. Each column was to be strong enough to attack or defend itself against any force of Indians it might meet, and from the convergence of their lines of march and the proximity of the commands after the Sioux country had been reached, it was expected that any band of Indians driven by one column would inevitably be thrown upon the advance of the other columns.

* Map not printed.

In this way it was expected the Indians would be deprived of the means of escape otherwise afforded by the broken character of the country in which they operated, and be forced to fight until subdued or annihilated, or to return peaceably to their reservations under the terms dictated by the troops.

Colonel Gibbon's command was comprised of six companies of the Seventh Infantry and four of the Second Cavalry, aggregating 27 officers and 409 men. It moved down the Yellowstone River on the north side and reached Fort Pease, at the mouth of the Big Horn, May 9, 1876. A scout was sent from the mouth of the Big Horn to Fort C. F. Smith, thence across to Tullock's Fork, and thence down that valley to Fort Pease, returning May 14. No Indians were discovered. The command continued down the river to the mouth of the Rosebud, where it encamped May 20. May 17 General Terry left Fort Lincoln with twelve companies of the Seventh Cavalry, Lieut. Col. George A. Custer commanding, one company of the Sixth Infantry, two companies of the Seventeenth Infantry, a detatchment of the Twentieth Infantry serving Gatling guns, and thirty Indian scouts, aggregating 45 officers and 905 men. Lieut. Edward Maguire, United States Engineers, accompanied the column.

The column marched almost due west to the headwaters of the Heart River, and reached the Powder River 24 miles from its mouth, June 7, 1876.

On the 19th, a supply camp was formed on the Yellowstone, at the mouth of the Powder River, and General Terry from this point communicated with Colonel Gibbon at the mouth of the Rosebud.

General Crook opened his second campaign on the 29th of May. His command was composed of five companies of the Second Cavalry, ten companies of the Third Cavalry, and three companies of the Ninth Infantry, and three companies of the Fourth Infantry, aggregating 33 officers and 959 men, and was accompanied by Capt. W. S. Stanton, Corps of Engineers. The column moved north from Fort Fetterman, along the Fort Phil Kearney route, to the headwaters of the south fork of Tongue River, called Goose Creek, where a temporary camp was established on the 15th of June, 1876. On the 16th of June, General Crook moved down the valley of Goose Creek, thence over the Tongue River divide, and struck the Indians at the cañon at the head of Rosebud, on the 17th of June.

He returned to Cloud Peak Camp on Goose Creek June 19. No report has been received of subsequent field operations from that camp.

Immediately after reaching the Powder River, June 7, General Terry sent Major Reno of the Seventh Cavalry, with six companies, to scout up the Powder River to the Little Powder, thence down Mizpah Creek, thence over the divide to Pumpkin Creek, and thence to rejoin the command at the mouth of the Tongue River. After reaching the Little Powder River, Major Reno departed somewhat from his instructions, and moved directly across the country to the Rosebud, which he reached 25 miles from its mouth. Here he discovered an Indian trail leading up the creek. After following this for 20 miles, Major Reno returned on his trail and rejoined his command at the mouth of the Tongue River on June 19. June 21, (just four days after Crook's fight at the Rosebud Cañon,) General Terry and Colonel Gibbon united their commands at the mouth of the Rosebud.

In accordance with a plan then determined upon, Colonel Custer moved up the Rosebud with his regiment on the 22d. After striking the Indian trail discovered by Major Reno, he rapidly followed it till

the morning of the 25th of June, when he suddenly came upon a large Indian village located on the left bank of the Little Horn, about 11 miles above its mouth. Major Reno was directed to cross the ford above the village, and make an attack on that side, while Custer led in person five companies in an attack on the north side, 3 miles below. Captain Benteen, with four companies, was held in reserve. Major Reno crossed the river, moved down 1 mile toward the village, and after encountering several attacks from Indians in large numbers, returned to the east bank, where he was joined by Captain Benteen and their position intrenched. But little is known positively of Colonel Custer's attack. This column reached the ford below, but could not effect a crossing, and on attempting to return it was surrounded by Indians and the whole command massacred after a bitter hand-to-hand fight. General Terry reached the mouth of Big Horn on the 24th of June. Colonel Gibbon's command was ferried across the Yellowstone in the afternoon and the advance toward the Little Horn commenced at once. Colonel Custer's battle-field was reached on the morning of the 27th, and Major Reno's command, which had been surrounded and several times attacked since the massacre, was rescued. After collecting the wounded and burying the dead, the united commands returned to the mouth of the Big Horn, where it is now refitting preparatory to a new campaign.

There are now *en route* to re-enforce this column four companies of the Twenty-second Infanty, 12 officers and 140 men, and six companies of the Fifth Infantry, 17 officers and 216 men.

To prevent Indians withdrawing from the Red Cloud and Spotted Tail agencies to assist Sitting Bull, and also to intercept war parties returning from Sitting Bull's command, eight companies of the Fifth Cavalry, under Lieutenant-Colonel Carr, were thrown out from Fort Laramie to Sage Creek, June 24, near the point where the Indian trail from the agencies to Powder River crosses that creek.

Captain Stanton and Lieutenant Maguire of the Engineers accompany, as I have stated, these expeditions, and though their surveying parties are small, it is expected that they will cover by their reconnaissances a large portion of the partially explored country comprised within the limits of the campaign, and will be enabled to make many important corrections to the maps of Northern Wyoming.

The engineer officers attached to the department headquarters are very zealous in the performance of their duties, but their operations are much circumscribed by the very limited facilities they have for executing work of an extended character. In collecting topographical information in the Territories, they have hitherto been compelled to rely to a great extent upon the itineraries kept by the officers and soldiers of the line engaged in scouting after Indian or Mexican marauders. These itineraries being kept by persons usually averse to duties foreign to their proper sphere, are necessarily imperfect and inaccurate, as the marches are long and the records entered hastily, and the engineer officers at department headquarters hesitate to use them except with great care and caution.

The only sketches of scouts or campaigns, in which any great confidence is placed, are those executed by the engineer officers themselves, or by assistants especially selected from among the junior officers of the line, whose attainments and disposition fit them for such duty, and by the enlisted men of the engineers detached from the battalion and assigned to duty in the departments.

The services of these enlisted men in this capacity cannot be too highly estimated, and it would be well if their number could be so increased that every engineer officer serving at department headquarters could

have at least four; so that a small party well trained could enter the field with every scouting party or expedition that is sent out during the season. I desire to particularly call your attention to this subject.

The engineer's office at headquarters Department of Texas has been in charge during the year of Lieut. William Hoffman, Eleventh United States Infantry. He has shown great interest in his work, and has given full and entire satisfaction to this office and to his department commander. He is at present at Fort Concho determining the longitude of that post, and the office is temporarily in the charge of Lieut. Hugh G. Brown, Twelfth Infantry, whose annual report is forwarded herewith.

I submit his report without modification, that you may have a clear idea of the manifold duties assigned to the officers at department headquarters, and of the importance of the officers and the office in the estimate of the department commanders.

As has been customary heretofore, I leave the engineer operations carried on in the Departments of Dakota, the Platte, and the Missouri to be reported upon by the officers in charge of the offices, repectively.

Amount required for surveys under direction of this Office during the fiscal year ending June 30, 1878, $6,000.

Very respectfully, your obedient servant,

GEORGE L. GILLESPIE,
Major of Engineers,
Chief Engineer Military Division of the Missouri.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers United States Army.

APPENDIX NN.

ANNUAL REPORT OF CAPTAIN WILLIAM LUDLOW, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pa., August 22, 1876.

SIR: I have the honor to submit herewith my report of operations for the fiscal year ending June 30, 1876.

In June, 1875, I was directed by the department commander to make a reconnaissance of the Carroll Road, a newly-opened freight-route extending from a point called Carroll, on the Upper Missouri River, through the Judith Basin, to Camp Baker, and thence to Helena, Mont. Ter. The reconnaissance was also to include an examination of the routes from the north into the Yellowstone Park, and the astronomical determination of the positions of the Montana posts.

A full report of this reconnaissance, accompanied by reports from Messrs. George Bird Grinnell and Ed. S. Dana, of Yale College, and Lieut. R. E. Thompson, Sixth Infantry, has been submitted.*

In anticipation of the active operations of this summer, I obtained from department headquarters an order detailing Lieutenant Worden, Seventh Infantry, as assistant, to act as engineer officer of the district of Montana, to accompany any movements of troops in Montana, and especially to look after the surveying duty with General Gibbon's column. For the purpose of aiding him in his operations, I sent out to him

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* Appended to this report.

Sergeant Becker and three men of my detachment of engineers, leaving myself with the same number. At the same time I was making as full preparations as possible to accompany General Terry's column with a surveying party.

Lieut. Edward Maguire, Corps of Engineers, however, relieved me on May 9, the date of General Terry's departure from Saint Paul for the frontier. Owing to the necessity that Lieutenant Maguire should follow as rapidly as possible, it was impracticable to make any transfers of property, &c, with the exception of the small balance of public funds then in my hands, for which Lieutenant Maguire receipted.

Very respectfully, your obedient servant,

WILLIAM LUDLOW,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.,
Washington, D. C.

RECONNAISSANCE FROM CARROLL, MONTANA, TO THE YELLOWSTONE NATIONAL PARK, IN THE SUMMER OF 1875.

HEADQUARTERS DEPARTMENT OF DAKOTA,
OFFICE OF THE CHIEF ENGINEER,
Saint Paul, Minn., March 1, 1876.

SIR: I have the honor to forward herewith a copy of my report of the reconnaissance of last summer from Carroll, Mont., over the Carroll Road, to Camp Baker, Mont., thence to Fort Ellis, Mont., including a brief tour through the Yellowstone National Park, and the return journey to Carroll. Accompanying my report, for incorporation therewith, are those of Messrs. Grinnell and Dana, which will be found both interesting and valuable.

A map of the reconnaissance is presented, which shows the authorities used, in addition to my own field-notes, which were made as complete as possible. Two sketches are added, one of the Judith Basin and the other of the Upper Geyser Basin, to be inserted in the proper places in the report.

A set of astronomical observations at Carroll, Camp Lewis, and Camp Baker, three principal points on the Carroll Road, are furnished; also a tabular statement of latitudes, longitudes, distances, &c., and a list of distances on the Missouri River, from a survey by the United States Boundary Commission. The region included within the limits of the Yellowstone Park is, for its area, the most interesting in the world. It is situated at the very heart of the continent, where the hidden pulses can, as it were, be seen and felt to beat, and the closely-written geological pages constitute a book which, being interpreted, will expose many of the mysterious operations of nature. My own interest in this land of wonder is so keen as to lead me again to hope that it will be protected from the vandalism from which it has already suffered, and that the suggestion of an accurate topographical and geological survey, to complete the work so well inaugurated by Professor Hayden, may be made the subject of favorable consideration and recommendation by the Chief of Engineers.

Very respectfully, your obedient servant,

WILLIAM LUDLOW,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.,
Washington, D. C.

CONTENTS.

MAPS AND ILLUSTRATIONS.

REPORT.

HEADQUARTERS DEPARTMENT OF DAKOTA,
OFFICE OF CHIEF ENGINEER,
Saint Paul, Minn., February 1, 1876.

SIR: I have the honor to submit herewith my report of the reconnaissance from Carroll, Mont., to Camp Baker, thence to Fort Ellis and the Yellowstone National Park, made during the months of July, August, and September, 1875, in accordance with the instructions given in Special Orders No. 110, dated Headquarters Department of Dakota, Saint Paul, Minn., June 14, 1875.

My report includes those of Mr. George Bird Grinnell on the paleontology and zoölogy and of Mr. Edward S. Dana on the geology of the region traversed. These reports will be found highly interesting and valuable. Drawings of fossils collected by Mr. Grinnell form a portion of his report.

Lieut. R. E. Thompson's report of the trip to the Judith Basin, and of the return from Carroll to Ellis, are also submitted; Lieutenant Thompson's topographical work having been incorporated in the general map.

A map of the route pursued is presented on a scale of six miles to the inch, and a tabular statement is appended to the report, giving the astronomically-determined positions of important points, tables of distance, instrumental observations, &c.

The determinations of Forts Shaw and Ellis are those of Lieut. F. V. Greene, Corps of Engineers, who was at those posts last summer on duty connected with the United States Boundary Commission. His labors obviated the necessity for my going to Fort Shaw, (which would have consumed some valuable time), and also saved me additional delay at Fort Ellis, at which place, out of six days I spent there, rain fell continuously for five.

The position of Fort Benton and the map of the Missouri River below that post are from the survey of the same officer, under direction of Capt. William J. Twining, Corps of Engineers, chief astronomer of the Boundary Commission, who with his party descended the river from Benton to Bismarck in Mackinac boats, at the close of the season's operations in 1874, carefully mapping it, and establishing almost daily astronomical stations. The river-distances determined by this survey show an enormous reduction from the crude and exaggerated estimates given in existing tables, and which have heretofore been accepted as fair approximations. Above Benton, the river is from the various published authorities collated, and as far as possible reconciled.

The topography adjoining the route is from the field-notes of the reconnaissance.

Sketches of the Judith and Upper Geyser Basins are given in the body of the report, also from field-notes.

The general topography of the Yellowstone Park is mainly taken from the published maps of Dr. Hayden and Captain Jones; using, however, my own latitude wherever good observations were taken. This, however, was but seldom, since showers fell every day but one that we were in the park, and the nights were almost invariably cloudy.

Inasmuch as no one who has seen this interesting region can fail to

be deeply solicitous for its care and preservation, I am impelled to express a hope for favorable consideration from the department commander of the remarks and suggestions in relation thereto.

I left Saint Paul on the evening of June 30, in obedience to Special Orders No. 110, series of 1875, from Headquarters Department of Dakota, and proceeded, via the Northern Pacific Railroad, to Bismarck, its western terminus, on the Missouri River.

[Special Orders No. 110.]

HEADQUARTERS DEPARTMENT OF DAKOTA,
Saint Paul, Minn., June 14, 1875.

Capt. William Ludlow, chief engineer of the department, will, on July 1 proximo, proceed, via the Northern Pacific Railroad and the Missouri River, to Carroll, Mont., and make a reconnaissance of the route from that place to Camp Baker. Having completed this duty, he will proceed to the several posts in the district of Montana, and determine their latitudes and longitudes. He will also, if time permits, make a reconnaissance from Fort Ellis to the Yellowstone Park. Captain Ludlow is authorized to take with him his assistant and the enlisted men of engineers under his command. He is also authorized to take with him a geologist and such other scientific gentlemen, not exceeding four in all, as may desire to accompany his party. The commanding officer of the district of Montana will furnish escorts to Captain Ludlow from point to point, wherever, in his judgment, it may be necessary, sending a party to Carroll for that purpose; the transportation being sufficient to furnish one wagon, one ambulance, and five saddle-horses for use of Captain Ludlow's party.

By command of Brigadier-General Terry.

O. D. GREENE,
Assistant Adjutant-General.

[Special Orders No. 127.]

HEADQUARTERS DEPARTMENT OF DAKOTA,
Saint Paul, Minn., July 7, 1875.

* * * * * * *

III. The Quartermaster's Department will employ one civilian guide and scout to accompany the reconnaissance under Capt. William Ludlow, United States Engineers, authorized in Department Special Orders No. 110, current series. He will be paid at the rate of $75 per month for the time he is actually employed, and will be furnished with transportation by steamboat for himself and horse from Bismarck to Carroll and return. The acting assistant quartermaster at Fort Abraham Lincoln will take him up on his "report of persons and articles."

IV. Second Lieut. R. E. Thompson, Sixth Infantry, report to Capt. William Ludlow, Engineer Corps, for duty as topographer, with the reconnaissance under the latter-named officer, authorized by Special Orders No. 110, current series, from these headquarters.

By command of Brigadier-General Terry.

O. D. GREENE,
Assistant Adjutant-General.

My party consisted (beside my brother, Mr. Edwin Ludlow, of New York, and assistant, Mr. W. H. Wood) of Messrs. George Bird Grinnell and Edward S. Dana, both of Yale College, who had come out to Saint Paul upon my invitation for the purpose of joining me.

These gentlemen traveled at their own expense, receiving no compensation for their services; and I cannot but consider myself extremely fortunate in having induced them to accompany me as special assistants. Mr. Grinnell would report upon the paleontology and zoölogy and Mr. Dana upon the geology of the country passed over.

The reports attest their zeal and industry, as well as the fullness of their qualifications for, and conscientious devotion to, their voluntarily-assumed tasks.

Special Orders No. 121 directed my detachment of engineer soldiers, consisting of Sergeants Becker and Wilson and five men, to report to me at Carroll for surveying purposes.

At Bismarck, the party was increased by the addition to it of Lieut. R. E. Thompson, Sixth Infantry, who was to accompany it as topographer and general assistant, and of Charles Reynolds, a well-known frontiersman, who was to act as guide and hunter for the expedition.

The instruments taken on the trip were a small Würdemann transit-theodolite, No. 94; a Spencer Browning & Co.'s sextant, No. 6536; a Gambay & Son reflecting-circle, No. 212; and two chronometers, a mean solar of Arnold & Dent, No. 1362, and a sidereal of Bond & Sons, No. 202. These instruments, with the exception of the circle, had been used on the reconnaissance to the Black Hills of the previous season, and were known to be good. In addition were four odometers, two thermometers, two aneroid barometers, and an odometer-cart, constructed for the purpose of measuring distances.

The party, after three days' detention at Bismarck, embarked on the steamer Josephine the evening of July 5, and sailed early on the morning of the 6th. Directions had been given Sergeant Becker to make a survey of the river while going up. This was continued during the day; but as night fell, and the boat continued to run, it was found impossible to take the necessary compass-bearings to points in advance.

Fort Stevenson, 84 miles from Bismarck, was reached at midnight. Here Lieutenant Thompson and Reynolds landed for the purpose of procuring some necessary articles, intending to join the boat again at Fort Berthold, which, although 25 miles above Stevenson by water, is only 7 or 8 miles by land.

July 7.—At 5 a. m. the boat reached Berthold, and stopped for two hours to land some freight, and Lieutenant Thompson and Reynolds again came on board. Berthold is the agency for the combined tribes of Rees, Gros Ventres, and Mandans, who occupy in common a village built on the north bank of the river, surrounding an old stockade of the Northwestern Fur Company, which had formerly a trading-post here. At that early hour the village was still asleep, and a stroll through it resulted only in arousing the numerous Indian curs that with snarls and threatening aspect resented the intrusion.

July 8.—Was hot and uneventful. Toward afternoon, the mosquitoes became more and more troublesome, and at night forbade sleep. About 11 p. m. the boat was stopped for the purpose of landing Reynolds (who had his horse with him,) and dispatching him in advance to Fort Buford, with a note to the post-quartermaster for supplies and one to the post-surgeon. A member of the party had been severely attacked with a disorder brought on by the heat and the effect of the river-water, which it is injudicious for one unaccustomed to its use to indulge in freely.

July 9.—Arrived at Buford, 300 miles above Bismarck, at 3 a. m. The surgeon, Dr. Middleton, kindly came down at once and announced that the invalid was suffering from a sharp attack, and that it would be in a high degree dangerous for him to proceed. I made preparations at once to go ashore and remain until the next succeeding boat, which would pass in a week or ten days, should enable me to continue the journey. Meanwhile Lieutenant Thompson would be in charge of the party, and instructions were given him to proceed to Carroll and examine thoroughly the neighboring country. A full opportunity would at the same time be afforded to determine the latitude and longitude of Carroll as a starting-point for the survey of the Carroll road, thence to Camp Baker, which might then be proceeded with immediately on my arrival.

July 15.—The Josephine returned to Buford from Carroll, having

safely landed the party, and brought a note from Lieutenant Thompson to the effect that the Indians had been very troublesome on the Carroll road, had run off a drove of 40 mules belonging to the Transportation Company, and had even boldly invaded Carroll and attempted to steal horses from the picket-rope.

I received information also that three recruits of a large detachment which had recently gone up the river, destined for Fort Shaw, had been killed in the immediate vicinity of Camp Lewis, 75 miles out of Carroll.

Under the circumstances, and feeling some apprehension for the safety of the party, which had an escort of ten men only, it was weary waiting at Buford for the next boat up, the arrival of which was delayed from various causes, until I had nearly determined upon the overland trip of 275 miles to Carroll, dangerous as this would have been, on account of the activity of the Indians and their large numbers in the vicinity of Fort Peck. However, the Key West at last arrived, on the morning of the 23d, and, hastily getting on board, the journey was resumed. Wolf Point, the Assiniboine agency, was reached at 10 p. m. of the 24th, and Fort Peck, the general up-river agency for the Sioux, on the evening of the 25th.

Peck, 180 miles above Buford by water, stands on a narrow plateau of the north bank of the river, almost overhung by the hills in rear. The buildings are of logs, one story, and inclosed within a stockade. This agency is the most considerable on the Missouri River. I was informed that from 8,000 to 10,000 people were fed there.

The distance to the hostile camps of Sitting Bull on the Yellowstone, is not much in excess of 100 miles, and intercourse is easy and not infrequent. It seems more than probable that in order to make up the large number which it is claimed is furnished with food and clothing from this agency, the Indians of the Yellowstone must be included, the attitude of whom is one of vigilant and unvarying hostility to all white men.

July 26.—Left Fort Peck at 3 a. m. Up to this point, the character of the river and its valley appeared to be measurably unchanged, a broad, rapid, and turbid stream, about 3 feet deep in the channel, cutting into its banks at every turn, sand-bars frequently appearing in the muddy bed; the valley heavily timbered with cottonwood, and well defined by hills. Above Peck, the bed of the stream became more gravelly, the channel consequently more stable, and the water somewhat clearer. The river narrowed to a width of from 150 to 300 yards; the clay bluffs from 150 to 600 feet in height, more closely approached the banks, and became exceedingly barren and unattractive, of dark-gray hue and ashen texture, with thin alkaline streaks near the base. Small plates of selenite scattered over the surface glittered in the sun, and the grass was exceedingly poor and scanty. As we advanced, small cedars appeared on the higher elevations, and game became more abundant. Glimpses of deer half-concealed in the shrubbery were frequently caught; large bands of elk were seen in the timbered "points;" and the shore of the river was everywhere dotted with the footprints of wild animals.

Three buffalo crossed the river in advance of the boat. One was killed and hoisted on deck; some Indians who had come on board at Wolf Point greedily appropriating the refuse portions. Just before sundown, a herd of 75 or 80 buffalo were seen dashing down the left bank in eager pursuit of three in advance, who had already entered the water and were half-way across the stream. The herd at once plunged in, and it was soon evident that the boat would intercept them. They kept on, however; the calves, of which there were several, swimming by the

lower side of the cows, and all making strenuous efforts to overtake the leaders, who had meanwhile climbed the opposite bank. The stupid animals only turned back when the foremost actually struck the boat with their heads, and then, with bovine snorts and bellowings, they heaped together and climbed upon each other in desperate fright, within a few feet of us. It would have been butchery to kill them, especially as we did not need the beef, and they were allowed to escape unhurt.

July 27.—Carroll was reached at 7 p. m. I found a note from Lieutenant Thompson to the effect that the vicinity of Carroll had been examined and the necessary observations taken; and, finding that forage and rations were becoming scarce, it had been determined to proceed on the road toward Camp Baker in order to save delay.

A courier was dispatched to Camp Lewis for escort and transportation by Lieutenant-Colonel Otis, assistant inspector-general of the department, who was *en route* to Helena, and we awaited the reply.

Carroll is a frontier "town" of perhaps twenty or twenty-five log buildings, on the south bank of the river, 640 miles above Bismarck and 165 miles below Fort Benton, the limit of navigation on the Upper Missouri. The town is situated on a timbered plateau 15 or 20 feet above the level of the stream at low water, in the river valley, which is some 800 to 900 feet in depth, with steep clay slopes covered with pine. It owes its existence to its being the terminus of the road recently opened from Helena, and the point at which freights are transferred to and from the boats.

Montana has long suffered from its isolation and from the want of an outlet for its productions. Until the opening of the Carroll road, the only regular communication with the outer world was by the road from Helena to Corinne, on the Union Pacific Railroad, a distance of over 450 miles. The distance from Helena to Carroll is more than 200 miles less than this, a difference which, to the heavy bull-trains averaging only 12 or 13 miles per day, represents a saving of 15 or 16 days in time. The Missouri River as far up as Carroll is generally navigable for the flat-bottomed stern-wheel boats that ply upon it until some time in October; and it is evident that by the aid of a connection at Bismarck with the Northern Pacific an important and valuable outlet for the wealth of the Territory has been discovered, available from the opening of navigation in the spring until quite late in the fall, a period of over five months.

In addition to the encouragement to the industries of Montana, a large saving can be made by the Government in the cost of transporting its troops and supplies for the up-river and Montana posts by the use of this route. These considerations, supported by the necessity for maintaining troops to act as a check upon the lawlessness of the large number of Indians annually congregating in the vicinity of Fort Peck, constitute an appeal to the Government to protect the road against forays by the Indians, an obligation which is recognized in the distribution of troops along the line of the road. At Camp Baker, 52 miles east of Helena, is a permanent garrison of two companies of infantry; at the forks of the Musselshell, 56 miles farther east, is a summer camp of two companies of infantry and one of cavalry; at the Judith Gap, 30 miles farther, is a detachment of eighteen or twenty men; and at Camp Lewis, 30 miles farther and 75 miles out of Carroll, is another summer garrison of two companies of infantry, from which a small detachment guards the stage-station at Box Elder, 40 miles out of Carroll. These posts can conveniently receive their supplies from Carroll.

If, in addition to the garrison at the forks of the Musselshell and Camp

Lewis, a force of cavalry, sufficiently large to patrol the road and push reconnaissances south and east, could be established between Camp Lewis and the Judith Gap—and in this range the requisites of wood, water, and grass are both excellent and abundant—the route could be made as permanently safe as any other highway, and such loss of property and life as occurred last summer be prevented. The truth of the general proposition cannot, I think, be questioned that the settlements of Montana can best be protected by troops removed from their immediate vicinity and pushed out toward the sources whence hostile incursions are to be apprehended.

July 30.—The stage came in at an early hour, bringing word from the commanding officer at Camp Lewis that, much as he desired to do so, he had no transportation or men that he could possibly send. Colonel Otis therefore hired such transportation as could be obtained in Carroll; and securing a few rifles and rounds of ammunition, we started soon after midday, our escort being half a dozen unarmed recruits, *en route* to Shaw.

The road out of Carroll leads up a long sharp ridge to the west, constantly ascending, with many turns, until an altitude of over 900 feet above the "town" is attained; the view thence was wide and varied. Up and down the river, the valley, sinuous and green, its steep slopes scored by deep ravines, could be traced for many miles. Bordering that, the tumbled Bad Lands on the south bank and the yellow prairie on the north, and in the distance the various ranges of mountains in detached groups—the Bear's Paw, 70 miles to the north and west; the Little Rockies, 30 miles north; the Judith Mountains, 40 miles south and west; with the Great and Little Moccasins close by, and the Snowies beyond.

The road at first traversed a rolling, sterile prairie, gradually descending. Camp was made on Little Crooked Creek, 13 miles from Carroll, and in what are called the Bad Lands, which extend out from Carroll for over 30 miles. The landscape is dreary to the last degree, with rolling and broken outlines. The soil throughout the region is a finely-ground clay of dark ashen hue and texture and irregularly striped by dirty alkaline streaks. In the absence of rain, it is dry and dusty; but thoroughly wetted, it becomes a greasy, slippery, fathomless mass of clinging mud, through which the straining animals can hardly drag the heavily-weighted wheels. Wood is almost entirely wanting; water is very scarce, and when found is alkaline and tepid. The vegetation is sage and cactus, with occasionally a little thin, poor grass. Near camp two trains were encountered going in to Carroll; they halted for the night 2 or 3 miles behind us.

July 31.—Camp was broken early, and the journey resumed through the same enlivening scenery for 20 miles, crossing Crooked Creek, a sluggish alkaline stream, deeply cut into the dark-gray clay, (where the sight of a party of mounted Indians some miles away disturbed our lunch and started us on the road,) to where the bounds of the Bad Lands were reached, and the road ascended upon high rolling prairie, over which a push of 7 miles led into the valley of Box Elder Creek. This is a stage-station, 40 miles from Carroll, where a guard of four soldiers is maintained from Lewis. The halting-place is marked by a log cabin standing on the bank of the creek, a small stream of swift-flowing water, which has its source in the slopes of the Judith Mountains. During the day, two or three single buffalo were seen, and antelope had appeared from time to time since leaving Carroll.

August 1.—The road led in a general southwest direction along the northern foot-hills of the mountains, which were eight to ten miles dis-

tant, rising steep and wooded to the height of some 2,000 feet. The road was good, although somewhat hilly, the grass fair, and the creeks, several of which we crossed, were all bright little streams of good water. As we advanced, the mountains began to define themselves. The Little and Greater Moccasins separated from the Judith and from each other, between them appearing the distant Highwoods, with patches of snow; the Snowies, to the south, also snow-crowned; and, separating them from the Little Belt, could be seen the depression which marks the Judith Gap. The road follows the western flank of the Judith, at the southwest extremity of which, on the banks of Big Spring Creek, finally appeared the garrison-flag and the white tents of Camp Lewis, 35 miles from Box Elder. The camp is situated in the level valley of the creek, the garrison consisting of two companies of the Seventh Infantry, Captain Browning commanding. The creek, the main affluent of the Judith River, rises a few miles above Lewis, in a huge spring, from which the stream emerges, full-grown, with a rapid, tumultuous current of ice-cold water, abounding with the black-speckled mountain-trout. The course is northwest in a gravelly bed 15 or 20 feet wide and 1 to 2 feet deep. Wood has in a great measure to be hauled by the garrison from the mountains, but the grass is rich and luxuriant.

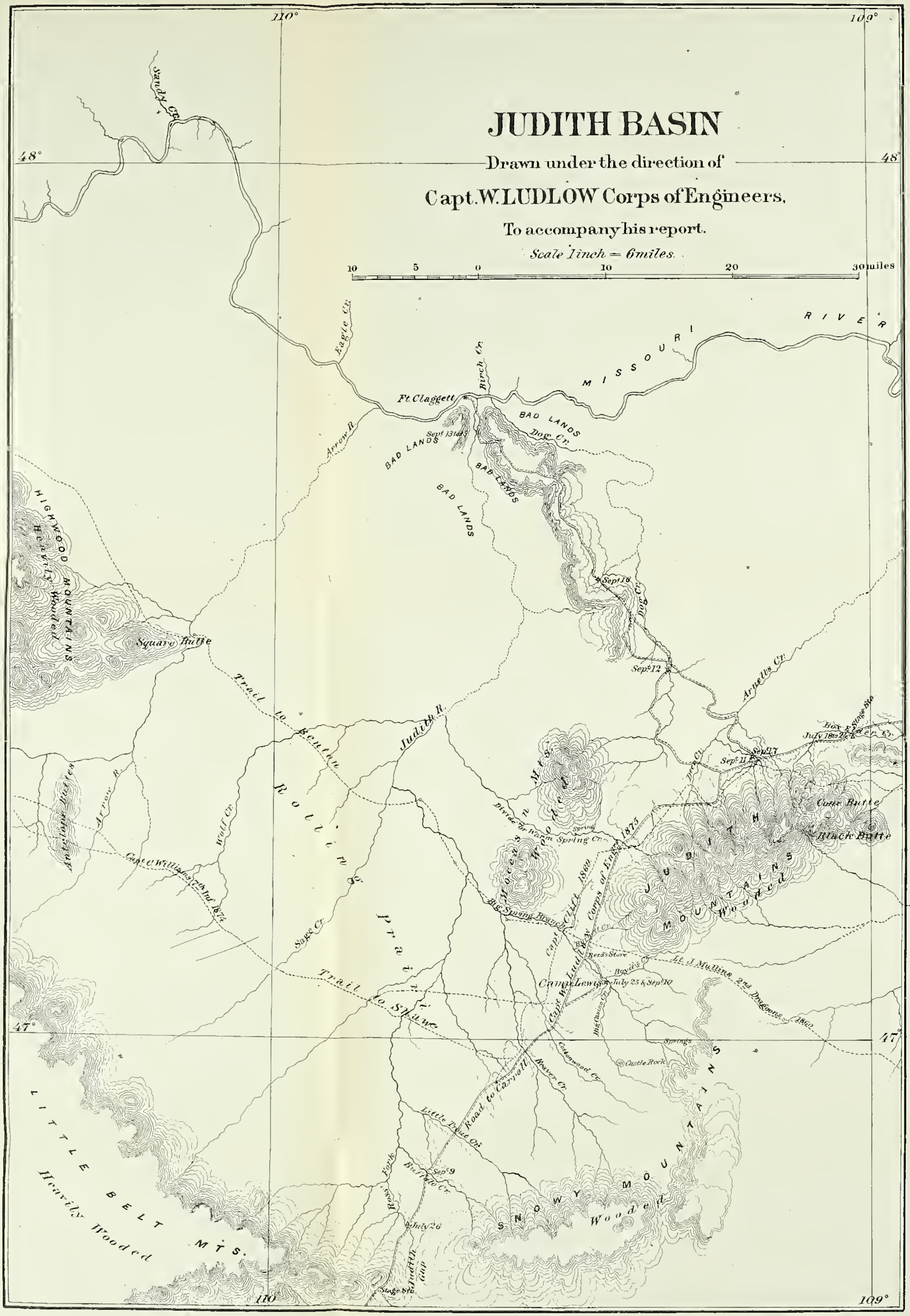
August 2.—Lewis is the second stage-station on the Carroll road, 75 miles from the "town." We lay over one day to rest the animals.

August 3.—Took the road again at an early hour, ascending upon a partly level and rolling prairie fairly grassed over, where rapid progress, parallel to the Snowy Range, was made, crossing several fine creeks which rise in the Snowies and flow north and west into the Judith River.

The Judith Basin, a sketch of which is given, opened to the north and west, showing a fine, well-grassed, gently-rolling prairie, some 50 miles east and west and 60 miles north and south, of irregular diamond-shape, and inclosing about 1,500 square miles, from the borders of which rose, massive and detached, the encircling ranges, the Judith, Snowy, Little Belt, and Highwoods. Throughout this elevated region (and more especially later in the Yellowstone Park) we had daily occasion to observe the marked depth and clearness of the coloring, owing, I presume, to the utter purity of the atmosphere; the colors of objects comparatively near by seemed to possess an unsurpassable richness and reality, and even on distant mountains, 75 or 80 miles away, while the colors were necessarily blended and their details lost, they exhibited a wonderful transparency and distinctness, undimmed by the haze and vagueness which usually obscure such distant objects. It is this quality of the atmosphere that furnishes the chief beauty of the Judith Basin, which can hardly be termed a mountainous country, although the various ranges grouped about it, and separated from each other by broad intervals, form the principal feature of the landscape. Painted in a clear, transparent purple upon the sky, and seeming hardly to rest upon the yellow prairie which forms so fine a contrast, they look like massive islands in the tawny ocean that rolls against them.

The basin will some day be a great stock-raising, and, by the aid of irrigation, an agricultural region. It has always been considered a fine hunting country, where game of all kinds could be found, although we saw none, with the exception of a few antelope; the recent presence of the Crow camp having driven it off.

At Ross's Fork of the Judith, near the gap, and 27 miles from Lewis, we met Lieutenant Thompson, who had come out from Baker with two spring-wagons to meet us. Camp was made, with good grass and fair water; wood scarce.



JUDITH BASIN
Drawn under the direction of
Capt. W. LUDLOW Corps of Engineers.
To accompany his report.
Scale 1 inch = 6 miles.
10 5 0 10 20 30 miles
110°
109°
48°
47°
Sandy Cr.
Eagle Cr.
Birch Cr.
MISSOURI RIVER
Ft. Claggett
BAD LANDS
Dog Cr.
Sept 13th 1875
Arrow R.
HIGHWOOD MOUNTAINS
Heavily Wooded
Square Butte
Sept 10
Dog Cr.
Sept 12
Armells Cr.
Trail to Benton
Judith R.
Rolling Prairie
Antelope Buttes
Arrow R.
Wolf Cr.
Capt. C. Williams 7th Inf. 1874
Sage Cr.
Trail to Shaw
Divide or Warm Spring Cr.
Spring
Big Spring Branch
Capt. Clift 1869
Capt. W. Ludlow Corps of Engrs. 1875
Reed's Store
Boyd's
Camp Lewis
July 25 & Sept 10
Lt. J. Mullins 2nd Dragoons 1860
Sept 11
Sept 17
July 18 to 24
Box Elder Cr.
Stage Sta.
Cone Butte
Black Butte
JUDITH MOUNTAINS
Wooded
Springs
Castle Rock
Cottonwood Cr.
Beaver Cr.
Road to Carroll
Little Trout Cr.
Sept 9
Buffalo Cr.
Ross Fork
July 26
Judith Gap
Stage Sta.
SNOWY MOUNTAINS
Wooded
LITTLE BELT MTS.
Heavily Wooded

August 4.—Pulled out at 6 a. m. The road led directly through the gap. From the southeast extremity of the Little Belt Mountains rises a fine spring, flowing east at first, and then doubling back through the gap into Ross's Fork.

The gap is formed by a depression 5 or 6 miles in width between the timbered Snowy and Belt Ranges. It constitutes the head of the Judith Basin; to the south appearing a broad, level stretch of prairie, sloping down to the Musselshell, 20 or 25 miles distant. The Crow camp at the time we passed was said to be 7 or 8 miles to the eastward, on the southern slope of the Snowies. We also heard that a fight had taken place two nights before between the Crows and a party of Sioux, and that a war-party of one hundred Sioux had passed subsequently through the gap, going northward.

Emerging from the gap, the road led west and south over a dry, sterile and dusty prairie, in the teeth of a blistering southwest gale, across Hoppley's Hole and Haymaker's and Daisy Dean Creeks, into the valley of the Mussellshell, whose freshness and greenness and abundance of timber afforded the strongest contrast to the country behind us. The hired teams were mortally weary, and had been with the greatest difficulty urged all day against the strong, hot wind. Released from harness, they ran to the bank and leaped bodily into the stream, thrusting their muzzles deep into the cool water with great contentment. The river is 25 or 30 feet wide, and on the average 7 or 8 inches deep, of clear, rapid flow, over a gravelly bottom; the valley level, wide, fertile, and richly grassed, with heavy clumps of timber on the low banks of the stream.

August 5.—Made an early start, and at 2 or 3 miles from camp came to the "forks" of the Mussellshell, where the north and south branches unite. Here a ranchman had established himself, raising cattle, and, by means of an irrigating-ditch, cultivating some 75 or 80 acres in oats and wheat. Throughout Montana, owing to the very thorough drainage, the general altitude above the sea, and the prevailing dryness of the atmosphere, irrigation is essential to successful agriculture.

A stage-station of the Carroll road is made at this ranch, 65 miles from Lewis and 56 miles from Baker.

The road followed west and north up the North Fork, passing through a rocky, wooded cañon of considerable beauty. Here the road, overlooking the stream, whose windings it followed, and deeply shaded by pines, made a very agreeable drive, the more so that we were now beyond any danger from Indians. Emerging from the cañon, the road led west and south over a high, rolling, and hilly prairie. At the foot of a long down-grade lay Copperopolis, which was found to consist of a mining shaft and a deserted shanty. The North Fork of Deep Creek was reached at 4 p. m. and camp made. The creek abounded with trout, and the wood, water, and grass were plenty and good.

August 6.—The road led down the valley of Deep Creek west and south to Brewer's Springs, where the luxuries of a hot bath, followed by a generous breakfast, were enjoyed. The waters well up freely, strongly impregnated with sulphur, from several springs, with temperatures varying from 105° to 115° Fahrenheit. They are taken up in wooden pipes, and introduced into the bathing houses. The odor is at first unpleasant, but the water is soft and thoroughly delightful to the skin. The color is a milky, cloudy blue, and soft, delicate filaments of sulphur adhere to the sides of the bath and stream from the mouths of the supplying-tubes. A small hotel has been built for the accommodation of visitors. At this point unite the two forks of Deep Creek,

which, bearing the name of Smith's River, flows here north and west past Camp Baker to join the Missouri. The Carroll road bifurcates, one branch going west over the mountains, the other following the rich and fertile river-valley, which supports thousands of cattle on its lush pasturage, until at 16¾ miles from the springs the road reaches Camp Baker, where it deflects to the west, toward Helena.

The post is an irregular-looking cluster of buildings planted in the midst of a level and stony plain, surrounded by mountains, upon which frequent patches of snow appear. An irrigating-ditch brings a current of water through the garrison, but hardly appears able to vivify the arid soil. The troops at Baker are two companies of the Seventh Infantry, Major Freeman commanding. I found here my party awaiting me, and without loss of time made preparations for the trip to Ellis. The transportation and escort which had hitherto accompanied the party had returned to Ellis, and as the road to that point was considered comparatively safe, a small force only was needed.

August 7.—Pulled out at 8 a. m., with transportation consisting of two six-mule teams and a four-mule ambulance, with saddle-horses for the party, and a sergeant and two men for guard and camp duty. There are two routes from Baker to Ellis: one, called the Duck Creek route, via the Missouri and Gallatin Valleys, is perfectly safe, being within the settlements, but several miles longer than the other, called the "outer" route, which, returning nearly to Brewer's Springs, goes up the South Fork of Deep Creek almost direct to Ellis, passing between the Crazy and Big Belt Mountains. From the springs south, the valley is at first broad and level and heavily grassed, the creek flowing northward. Many antelope were seen grazing in the meadows. Camp was made at 3.30 p. m. near a fresh, cold spring issuing from the hill-side on the east bank of the creek. The locality is the ordinary halting-place, 27 miles out of Baker, and is called Moss Agate Springs. The grazing and water are excellent, but the supply of wood is small.

August 8.—Course continued nearly south up the valley. The creek gradually became smaller and finally was dry. "Sixteen-mile Creek," a branch of the Missouri, flowing a strong current west and south, was crossed 11 miles from camp, and the road beyond lay over a dry, yellow, gently-undulating prairie, which farther on grew more hilly, and became an interminable waste of sage-brush. The antelope were numerous during the day. Cottonwood Creek, a small branch of Shield's River, was crossed 13½ miles from Sixteen-mile Creek. The water is pure and plenty, and the valley well supplied with cotton-wood trees. Continuing, the sage-brush still occupied the ground, and camp was finally made on a small creek flowing east, the valley of which furnished an ample supply of excellent water and grass, and wood sufficient for camping purposes. Bridger Pass appeared 7 or 8 miles south of us, and Flathead Pass opened to the westward through the Big Belt Range.

August 9.—Pulled out at 6 a. m. The trail led into a broad valley, stretching eastward at the foot of the mountains, richly grassed, intersected by several small streams, and affording the finest pasturage for three or four herds of cattle which were browsing in the meadow. These had probably been driven over the mountains from the Gallatin Valley for the summer. Crossing the valley brought us to the foot-hills of Bridger Pass, which, though much lower than the neighboring mountains, still gave promise of an arduous climb for the heavy wagons. A creek flows out of the pass, up the valley of which a road of fair grade could be easily constructed. In the absence of this, the trail climbs several steep hills in succession, alternately ascending and descending,

but constantly rising, though with more than double the necessary labor, until at the summit of a long, sloping hog-back, falling steeply on both sides, a preliminary divide was reached, whence descent was made, following a small branch, into the valley of Brackett's Creek. This is a tributary of Shield's River, flowing eastward and separating the group of mountains over which we had passed from the main range, the pass through which still lay before us. Crossing the creek, the second ascent was found to be more gradual and less severe than the former, although of about equal altitude. Reaching the second summit, the descent began down the left bank of Bridger Creek, flowing southward. The peaks to the west across the valley were lofty, varied in form, and from certain points of view exceedingly fine. Huge patches of snow rested in the more sheltered places on their summits, and one could begin to realize the altitude of 10,000 feet above the sea, which sufficed to maintain this wintry feature even under the clear, hot rays of the summer sun. The timber throughout the pass is pine, with various small woods in the creek-bottoms. Grass is abundant, even among the timber, and the brooks are bright mountain-streams constantly fed from the snow-fields above, and abounding with trout. Elk and deer are numerous, though they are driven from the immediate vicinity of the trail by frequent travel, and possibly by the flies, which in great numbers and varieties proved a serious annoyance to the cattle. Still following Bridger Creek, the road made a long bend to the south and west, around the base of Bridger Mountain, into the main valley, which turns west to join that of the Gallatin. Crossing the creek, the trail wound over a range of hills and descended into the valley of the North Gallatin, upon the south bank of which, 3 or 4 miles farther west, Fort Ellis is situated. The Bozeman Pass road, leading east and south to the Yellowstone, climbs the hill-side opposite to where the road reaches the river.

Fort Ellis stands near the head of the Gallatin Valley, for the defense of which it was constructed. It appears as an assemblage of log houses, irregularly placed from frequent additions, of uninviting exterior, but comfortable within. The garrison, General Sweitzer commanding, includes four companies of the Second Cavalry and one of the Seventh Infantry; but during the summer the mounted troops are required to guard the passes and make frequent scouts, sometimes of considerable extent, and hence spend but little time in garrison. At the date of my arrival, two companies were absent, one scouting, the other acting as escort to the party of the Secretary of War in the Yellowstone Park, while a third was preparing for the field, and started early next morning.

August 10.—Employed the day in preparations for the trip to the park. The greater portion of the necessary pack-animals were then in the park, and my arrival was fortunately timed, since they were on the return, and expected back in two or three days. By advancing to meet them, double that time could be saved. Accordingly, the baggage was reduced to the smallest possible amount. All trunks and boxes were left behind, and the necessary articles put into canvas sacks, brought from Saint Paul for the purpose. Tents were discarded and only tent-flies carried. The instruments were carefully rolled in bundles of bedding, and the basket containing the chronometers strapped to the spring-seat of the odometer-cart. Riding-animals were obtained and a six-mule team secured to carry the baggage and stores until the pack-train should be met. Toward evening we went into camp about three miles southeast from Ellis, on Coal or Rocky Cañon Creek, a small affluent of the Gallatin, uniting with it near the fort.

August 11.—Broke camp at 6 a. m., and proceeded across the creek and up its valley. The trail followed the creek-bottom, crossing it several times, and over a rocky, hilly road, through a cañon of considerable grandeur, shaded by lofty, precipitous limestone pinnacles. The general course was south and east, up the east bank of the creek, gradually ascending and bending more to the southward. The road improved, the available space becoming greater and the hills less steep. Crossing a low divide extending across the valley, the head of Trail Creek, a tributary of the Yellowstone, was reached. Through both creek-valleys, the flies were very numerous and annoying. There are two ranches on Trail Creek, the second one 25 miles from Ellis, where the creek-valley widened and entered that of the Yellowstone, which presented the familiar features of a broad, dry, stony stretch of prairie, sloping down to a beautiful stream, with borders fringed with trees. The river has a stony and gravelly bed, an impetuous current of six or seven miles an hour, a depth of as many feet, and width of about 100 yards. The waters, constantly freshened by mountain springs and torrents, are cold and clear, and alive with trout of great size and variety. These range in weight from half a pound to two pounds and upward. Their favorite food is the grasshopper, great numbers of which fall into the stream, but they will also take the fly freely.

The Snow Mountains border the river on the south and east, their lofty pinnacles glittering with snow. Chief among the range is Emigrant Peak, rising 6,000 feet above the valley and attaining an altitude of 11,500 feet above the sea. It is a very handsome mountain, of fine outline and great richness of coloring. Débouching from Trail Creek, the road bends south and west up the left bank of the river. We here met the party of the Secretary of War, in two spring-wagons, going in to Ellis. The pack-train had been left behind at Gardner's River Springs, to follow more leisurely. Pushing on up the valley, crossing several small brooks flowing from the mountains, and passing two or three ranches, camp was made near Bottler's ranch, half-way to the Mammoth Springs and 35 miles from Ellis. Sufficient wood was readily attainable, and a swift-flowing brook was close at hand; but the grass, never luxuriant, had been thinned by frequent camping.

August 12.—Broke camp at 8 a. m. The road passed Bottler's ranch, where travelers can find fairly good food and lodging, and proceeded up the level valley to a rocky point coming down from the mountains to the river-bank. Surmounting this, we followed up the valley again, crossing two or three rude but sufficient bridges, at one of which was a toll-house. It appeared that a company in Bozeman had obtained a territorial charter for a toll-road from that place to the Mammoth Springs. The road had been made practicable for wagons, and considerable work expended upon it up to the toll-bridge; but the main labor directed to the cañon above, which had hitherto been a serious obstacle and impassable to vehicles. Continuing, the road bent more to the south, and entered the cañon, following a hilly trail, blasted out of the rocks. The cañon is some 3 miles in length, and the view from the highest part of the road is very fine. The river, compressed to a width of 75 or 80 feet, is of a rich green hue, splashed with white, and flows with great velocity; its surface breaking into great waves and swirls. The mountains on either side are 2,000 or 3,000 feet in height, rising precipitously from the brink, and exhibiting dark browns and grays, contrasting with the deep, somber hue of the pines and the more sparkling green of the river, flecked with foam.

Camp was made at the upper end of the cañon, on the bank. All

the essentials for camping were present, and trout abounded in the swift and turbulent waters. The grayling, a long, slender fish, of less weight than the trout, but rivalling it in activity and game qualities, competed successfully for the fly with the larger fish.

August 13.—Started at 6.30 a. m., and soon afterward met Lieutenant Doane, with the pack-train. The six-mule team was exchanged for pack-mules, and, after some three hours' delay, the journey was resumed.

Cinnabar Mountain stands in the valley, on the right of the trail, and, as seen from any point of view, is a handsome peak. Looking from above it, on the river-bank, it stands out from the other elevations and makes a very striking picture. The strata are nearly vertical, with a perceptible overhang to the eastward, and strike nearly north and south. On the south front of the mountain is an immense "Devil's Slide," with smooth, dark, nearly vertical walls, some 150 or 200 feet in height, (the intervening material having been removed,) which curve to the right in ascending and reach the summit. Adjoining this are broad bands of red and yellow, which follow the same curve, and seize the eye at once from their brilliancy of color and vivid contrast.

The trail led us on up the valley, past two ranches, from which supplies were obtained, to within a few miles of Gardiner's River. At this point it leaves the valley of the Yellowstone, and, over a hilly route, passes across the angle between the two streams, until, at the farther side of a level, well-grassed piece of prairie, it reaches the valley in which the Mammoth Hot Springs are situated. The rain had descended heavily all the afternoon and continued into the night.

August 14.—The day opened wet but cleared in a few hours. A thorough examination was made of the springs, which well repaid it.

They have been already described with great particularity and minuteness in the reports of Dr. Hayden and Captain Jones, and a few words of description from me will suffice.

This remark is not to be confined to the locality of the springs, but must be understood as applying, and in a still greater degree, to the whole park, of which I shall not even attempt a full description, but content myself with recording only a few of the more prominent and enduring impressions received in our hurried visit.

Pressed for time, with other work to do, our constant idea was one of eager haste, and we passed rapidly from place to place, thoroughly enjoying every hour, but always with some new wonder in advance, to divert our attention and to draw us on.

The park scenery, as a whole, is too grand, its scope too immense, its details too varied and minute, to admit of adequate description, save by some great writer, who, with mind and pen equally trained, could seize upon the salient points, and, with just discrimination, throw into proper relief the varied features of mingled grandeur, wonder, and beauty.

The Mammoth Hot Springs are the first point of interest in the park, the northern boundary of which was crossed yesterday some miles back. They occupy a small valley, discharging eastward into that of Gardiner's River, and which the spring-deposits have partly filled. Our camp was pleasantly situated in the valley below the springs, among trees growing out of these deposits, in which occasional pits and holes 15 to 20 feet in depth existed. Above the camp rose the extinct spring, called, from the shape of the mausoleum which it had itself constructed, the "Liberty Cap," or "Giant's Thumb," and beyond this again

a succession of terraces, rising to a height of some 200 feet, dazzling white in the sun, indicated the presence of the active springs, which indeed had all along been evident enough from the vast clouds of vapor constantly arising. The terraces exhibited great variety and beauty of form, much enhanced by the quivering and sheeny effect of the thin descending sheets of water.

The material is a carbonate of lime, deposited by the cooling of the waters, of a nearly pure white, and while wet of a moderate hardness. Upon drying, the deposit becomes soft and friable, and a hunting-knife could be easily plunged into it to the hilt. The main springs occupy the upper portion of the terrace, and spread out into large limpid pools of a superb blue tint, boiling violently in places and emitting clouds of steam. Overflowing the pools, the waters escape down the face of the terraces, and in cooling gradually part with the carbonate held in solution, making constant additions to the ornamentations of the surfaces, and constructing scalloped pools and "bath-tubs" of every form and temperature.

The whole vicinity of the springs returns a hollow echo to the tread, highly suggestive of pit-falls beneath. The party, however, overran the neighborhood, at first with tentative step, and afterward with all confidence, no accident occurring. Remains of extinct springs abound above and below the active ones, while still others in full flow exist near the river's edge.

The grass in the valley of the springs is poor, but on the small prairie above is excellent. Wood and cold water are sufficiently abundant and convenient.

There are two "ranches" near the springs, which do duty as "hotels," and are available for the use of travelers.

August 15.—Wagons can be taken as far as the springs without much difficulty; the road having been made entirely practicable, though of an occasionally undesirable steepness. At the springs, however, wheels must be abandoned, and everything carried upon pack-animals.

The odometer-cart was left behind, both on account of the difficulty of getting it along and the danger of rendering it unfit for use on the return trip to Carroll. The mean solar chronometer was left with it, in charge of the "hotel"-keeper, and the sidereal was rolled in a bundle of bedding, and intrusted to the somewhat uncertain fortunes of the packs. All other reductions had been made at Ellis, and camp was broken at 8.15 a. m.; the "outfit" consisting, besides the party and the engineer soldiers, of three packers, a farrier, and a cook, in all twenty-two persons and thirty-three animals, of which eleven were pack-mules carrying about two hundred pounds.

The trail (a bridle-path only) leads up the valley of Gardiner's River (which is of considerable depth, and slopes steeply down to the water's edge) across the West Fork, and then the East, gradually climbing the eastern side of the valley to a plateau, whence on the right of the trail descend the waters of the river, and form a very pretty fall. The slopes of the river-valley are composed of loose basaltic *débris*, making a toilsome path, deeply gashed in places by washings from the foot of the great basaltic wall which towers above it on the east. Although not insecure, the ascent to the plateau is unnecessarily difficult, and a little labor expended upon it would serve to improve it greatly.

The falls are some 20 feet in width, and make three plunges, estimated at about 45, 55, and 30 feet each; in all a descent of 130 feet.

Leaving the river, the trail follows up in an easterly direction the shallow valley of a small brook called Black Tail Deer Creek, which

traverses an open hilly prairie, and affords an excellent and easily-traveled road. Reaching the head of the creek, the trail bore to the right, through a dry cañony place to the edge of the valley of Meadow Brook, where, turning sharply to the left, it descends along a steep high slope, out of which the narrow trail is cut, to a fine open meadow, well grassed and watered, where camp was made, 13 miles from the springs. Several of the party rode on, a mile and a half farther, to the Yellowstone River. It was found to be a foaming torrent, some 60 feet in width, with steep, rocky banks. The water, a rich green in hue, was broken into pools and eddies by obstructing bowlders, and a strong odor of sulphur pervaded the air. Spanning the stream is a rough bridge some 80 feet in length, resting upon cribs at either extremity, and affording a passage to the east bank, where, at a short distance from the "bridge," is the "ranch" of Jack Baronet.

Two or three miles below the "bridge," the two forks of the Yellowstone unite, and, to the traveler approaching it, the locality is marked by a large, flat-topped butte, with steep escarpments, which stands in the angle, and from its shape is a noticeable object, contrasting with the pointed hills and peaks which surround it. The West Fork drains the lake, and the East, a mountainous district not yet thoroughly examined.

Rain fell again during the afternoon and night, and our experience of the weather in the park seemed to be similar to that of Captain Jones, as recorded in his report. On one day only of the two weeks passed in the park did we fail to have rain or shower, and night observations were in consequence greatly interfered with.

August 16.—Camp was broken at 8.30. The herd had wandered during the night, and a couple of hours were lost in getting them in and ready for the road. The pack-mules had been employed on similar duty just before, and heavily laden. The construction or adjustment of the army pack-saddle is doubtless capable of great improvement; at any rate, the backs and shoulders of the animals were in very bad condition, and one of them was found to be so unfit for a load that it was necessary to leave him at the bridge.

While in the park, as there was no grain for the animals, they were allowed free range at night, and the grazing is so plentiful and nutritious that the majority of them held their own, although the work was occasionally severe. There need be little or no apprehension from Indians, and guards were not posted after leaving the Mammoth Springs.

The trail from Meadow Brook leads up the left bank of the Yellowstone, winding among some low hills, and at 4½ miles from camp makes a precipitous plunge into the valley of Tower Creek, crossing which it ascends the opposite bank by a more gradual incline. The stream is a strong rapid brook, 12 or 15 feet in width, and a foot or two in depth, with a stony bed, the waters fed from the snow-fields of the mountains. A short distance below the crossing are the falls, which leap down 150 feet into a narrow, dark cañon some 480 feet in depth. Basaltic-tufa cones and columns in the vicinity of the fall have suggested the name, and all the surroundings are picturesque in the highest degree. The finest view of the falls can be gained from a projecting spur on the south bank just below them, whence both the cañon and the creek-valley above can be seen. The stream discharges into the Yellowstone River near by, and at its mouth very fine fishing rewards the visitor.

There seem to be two varieties of trout here, the bulky ones of the Yellowstone, with bright-yellow bellies and stripings of red, and a smaller kind more silvery in appearance, and exhibiting much greater activity and game qualities. These latter seemed to come generally

from the creek. The mouth of the creek may be called the lower end of the Grand Cañon, which extends up the river some 16 miles to the foot of the Great Falls.

Leaving the creek, the trail, alternately rising and falling, and curving to the right and left, gains the foot of a long, somewhat rolling ascent, which finally attains the western shoulder of Mount Washburne. The flanks of this incline fall steeply on both sides, displaying to the west an ocean of deep-green pine, surrounded by ragged, bare pinnacles, and to the east breaking into the foot-hills of Washburne. This incline is approximately located on Raynolds's map, and called the Elephant's Back, which name has on some later maps been transferred to a minor elevation near the Yellowstone Lake. The name is appropriate and descriptive, and, having been given by the first topographer of the region, should be allowed to have its original application.

Over this the trail by a gradual ascent reaches a high point on Mount Washburne, passing between banks of snow, which had remained unmelted by the summer's sun. Here, leaving the trail, the party ascended to the summit of the mountain. The climb was made in less than an hour, and can almost be accomplished on horseback, so rounded is the mountain-top, although consideration for the saddle-horses would suggest making it on foot. In passing some stunted pines near the trail, it was observed that there were no branches or twigs on the northwest side of the tree, and that those which sprung from the northeast and southwest sides were twisted back and trailed away to the southeast. The explanation of this was not long in doubt. Reaching the summit, the whole panorama of the park sprung into view: the lake, with deeply sinuous shores and silver surface, interspersed with islands, with the Yellowstone River crooking away from it toward us, was set, as it were, in a vast expanse of green, rising and falling in huge billows, above which here and there jets of steam arose like spray; the encircling peaks, ragged and snow-clad, almost too numerous to count; Mount Humphreys, 30 or 40 miles southeast, Sheridan and Hancock the same distance to the south, and beyond and above them, 90 miles away, looking almost mysterious from their distance and vast height, the Tetons, of a pale purple hue, with their piercing summits glittering like icebergs. Only to the southeast, looking toward the great Idaho Desert, did a space appear which showed no prominent peaks. We had scarcely time to more than glance at this superb landscape, while resting and eating lunch with the aid of a hatful of snow from a neighboring bank, when a ferocious squall of hail, rain, and snow burst upon us from the northwest, and swept us like dust from the bald summit of the mountain. We were instantly compelled to seek shelter on the lee side, where, cowering and half-frozen, we awaited the passing of the storm. Motion, however, was absolutely essential to warmth; so, without again trusting the untender mercies of the mountain, over which the wind still blew keen and cold, we plunged into a deep ravine leading steeply down its western flank, and regained the trail at the foot. The storm had wet the rich black mold, and made the path slippery and difficult through the densest timber of spruce and pine, where hardly sufficient cutting had been done to afford the narrowest of passage-ways. The projecting branches flapped back their freight of raindrops into our faces and clothing, and many of the broken twigs bore trophies snatched from the packs.

There were several sharp pitches into and out of the valleys of small brooks, which could easily be avoided. At present, the trail is unnecessarily hilly and fatiguing, although delightful on account of the fine

forest and the great number and variety of the flowers. The grass is everywhere luxuriant and sweet, the brooks are frequent, and flow in all directions, and camp could be made at almost any point. The trail, however, might be greatly improved by means of a little well-directed labor and the exercise of better judgment in selecting it. The work of a pack or saddle animal is vastly increased by unnecessary ascents and descents, which both their conformation and the position of the load render arduous, and the easiest road is one of even grade, though it be thrice the length of the more direct one.

Ascending to a low divide between two mountains, the valley of Cascade Creek was reached and followed to camp. The last three or four miles were over a meadow which in many places was wet and very boggy. The hail here had fallen in considerable quantity, and whitened all the ground; the sky was dark, and the air raw and wintry. Camp was made on the east bank of the creek, where it leaves the meadow and enters the narrow, steep valley through which it reaches the Yellowstone. A roaring camp-fire soon restored the warmth and cheerfulness of the party, which had been somewhat impaired by the shivering weather. We were only about a mile from the falls, and after everything had quieted down to silence their deep roar became vaguely audible. The evening was again cloudy and rainy. Distance traveled during the day estimated at eighteen miles.

August 17.—Lay over in camp to visit the falls. The night had been cold, and by 8 a. m. the hail of yesterday had not disappeared. Waiting an hour longer for the sun to dry the heavy grass, we took on foot the trail which led us to the brink of the river-valley, half-way between the upper and the lower fall, which are half a mile apart. Reserving the lower fall, whose deep thunder we could now plainly hear, we descended toward the upper, and, after a short scramble over loose trachytic blocks, climbed out upon a point which, projecting into the cañon below the fall, furnished a fine view of it almost *en face.* The river makes a sharp bend to the eastward just above the fall, which in consequence fronts nearly at right angles to the general direction. From the sharp and narrow pinnacle on which we stood, or rather to which we clung, the cataract, some 150 feet distant, was exposed in its full height and beauty. It is a slanting one, having a base of perhaps one-half its altitude, which, as measured by a cord brought for the purpose and marked in 10-foot lengths, is 110 feet. The water leaps down its rocky slope between black, shining walls of trachyte, and its pure green is broken into foam and spray from the very summit. From the foot the currents of air drove the clouds of vapor up the steep sides of the cañon, which were clothed in vegetation of the freshest and most brilliant hue, while a double rainbow illumined the surface of the stream below. The picture was certainly a beautiful one, and we hung over it in delight for an hour, which, with the thunder of the lower fall still fresh in recollection, was all the time we could afford. Half an hour of rough climbing over bowlders and loose trachytic blocks, across Cascade Creek, and down the side of the main valley, brought us to a small plateau at the very crest of the main fall, and almost at the water's edge, where the eye could plunge into the vast chasm below the fall, known as the Grand Cañon. I had not time to think of it then, but was afterward not a little amused to remember that we passed on the way one of the men, who, seated on the bank, was pensively watching for a trout to seize his grasshopper. He had evidently wearied of too much bacon and scenery, and proposed a change at least of diet.

The view of the Grand Cañon from the point where we stood is per-

haps the finest piece of scenery in the world. I can conceive of no combination of pictorial splendors which could unite more potently the two requisites of majesty and beauty.

Close at hand, the river, narrowed in its bed to a width of some 70 feet and with a depth of 4 or 5 feet, through the pure deep green of which the hardly wavering outlines of the brown bowlders beneath are distinctly visible, springs to the crest with an intensity of motion that makes its clear depths fairly seem to quiver. Just before making the plunge, the stream is again contracted, and the waters are thrown in from both sides toward the center, so that two bold rounded prominences or buttresses, as it were, are formed where green and white commingle. Lying prostrate, and looking down into the depth, with the cold breath of the cañon fanning the face, one can see that these ribs continue downward, the whole mass of the fall gradually breaking into spray against the air, until lost in the vast cloud of vapor that hides its lowest third, and out of which comes up a mighty roar that shakes the hills and communicates a strange vibration to the nerves. From far below this cloud emerges a narrow, green ribbon, winding and twisting, in which the river is hardly recognizable, so dwarfed is it, and creeping with so oily and sluggish a current, as though its fall had stunned it. On either hand, the walls of the cañon curve back from the plunging torrent, and rise weltering with moisture to the level of the fall, again ascending 500 or 600 feet to the pine-fringed margin of the cañon; pinnacles and towers projecting far into the space between, and seeming to overhang their bases.

These details are comparatively easy to give, but how find words which shall suggest the marvelous picture as a whole! The sun had come out after a brief shower, and, shining nearly from the meridian straight into the cañon, flooded it with light, and illuminated it with a wealth and luxuriance of color almost supernatural.

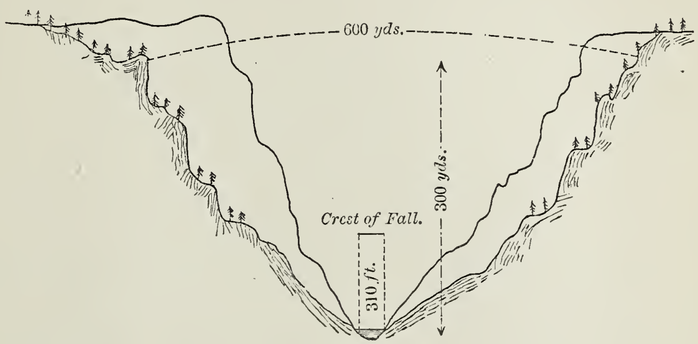
The walls appeared to glow with a cold, inward radiance of their own, and gave back tints of orange, pink, yellow, red, white, and brown, of a vividness and massiveness hopeless to describe, and which would overtax the powers of the greatest artist to portray. The lower slopes, wet with spray, were decorated with the rich hue of vegetation, while through the midst the river, of a still more brilliant green, far below pursued its tortuous course, and the eye followed it down through this ocean of color until 2 or 3 miles away a curve in the cañon hid it from view and formed its own appropriate background.

The height of the fall, as ascertained by attaching a heavy weight to the measured cord, and lowering it down, is 310 feet. The first attempt to get the height was made from the little plateau by the side of the crest, but the spray soon hid the weight from view, and the water so tore at it that it was impossible to tell when the bottom had been reached. A point was found, however, to the left and in advance of the crest and some 80 feet above it, from which the weight fell nearly vertically, and, by aid of the colored tags which marked the intervals of the cord, could be followed with the eye until it reached the brink of the stream below. From this same point, a sort of perch upon the very border of the precipice, can be had a most comprehensive view at once of fall and cañon.

After making the measurement, we ascended the side of the cañon, and climbed out to one of the projecting pinnacles, half a mile farther down stream, whence a full view of the fall was obtained. It was remarkable to note how small a portion of the view was actually filled by

the fall itself. Tremendous as it is, it seems but a minor incident in the picture constructed on the huge scale of the cañon.

From the projecting point, the width of the chasm across the top was estimated from the range of a carefully-sighted rifle at 700 yards. This, however, is greater than the average width, the cañon just below narrowing considerably and gaining at the same time in depth, which is about 300 yards. The corresponding cross-section would be similar to that in the accompanying sketch, which is intended to show the dimensions just below the fall, and another section farther down.



Sections of cañon just below the Lower Fall and farther down. Scale, 600 feet to 1 inch.

The descent to the bottom of the cañon from the east side is comparatively easy. From the west side it has also been accomplished, but it is toilsome and not unattended with danger, and the time necessary to descend and return would be considerable. Among other improvements that suggest themselves to the visitor as proper to be made in the future is the construction of facilities for making this descent, such as rude but strong ladders, which could readily be placed in position where their aid would obviate all danger and decrease the fatigue. One of the party made an attempt to get down, but lost time in looking for the most favorable place, and, the afternoon waning, he was compelled to abandon the undertaking.

August 18.—The morning opened cold and foggy. Camp was broken at 8. Took the trail which crosses Cascade Creek near the river by a steep pitch, and after a short ride over hilly ground and through timber reached comparatively open ground on the bank of the river, which was there 100 to 200 yards wide, and peaceful enough, flowing with smooth, gentle current, between low, grassy banks. The pack-train meanwhile had taken a trail somewhat farther to the westward, which avoided the steep descent into Cascade Creek and made an easier crossing of it. The two trails united at a small creek discharging into the river, crossed it, and through dense timber climbed around the shoulder of a mountain to again descend into the broad open valley of Alum Creek. This is a shallow, sluggish stream of tepid, undrinkable water, some 30 feet in width and an inch or two deep, with a general northeast course to the Yellowstone. Off to the right, across an open prairie, appeared the Sulphur Springs, or Soda Mountain, as it has been called, which we visited. Some 40 or 50 acres are covered with extinct and active springs and their deposits. Pure sulphur in considerable quantity is distributed over the surface. Several springs were boiling violently, one of them to a height of 3 or 4 feet, and emitted large volumes of steam. Pursuing the course again

toward the river, over a hilly prairie, and crossing one or two creeks and arms of the river, and a broad meadow, the borders of which were springy and boggy, the trail led to the edge of some timber, soon after entering which the Mud Geysers were found. We passed on to a small pine grove, favorably situated for camp near the river and 12 miles distant from Cascade Creek. Leaving the horses, we returned on foot to examine the geysers. The main one is a bubbling pool of muddy, hot water some 50 or 60 feet across, with a sloping shore 4 or 5 feet high, and numerous small vents and springs within the perimeter. The water is thick with gray, unwholesome-looking mud, and exhales a fœtid odor.

Another geyser, much more impressive in appearance, which however has not been seen to spout, at least of late years, has a crater some 50 feet in diameter and 25 feet deep, narrowing at the bottom to a mud pool of the consistence of boiling mush, about 15 feet across. From the northwest side of this a perpetual boiling takes place, with a threatening roar and huge clouds of steam. If the mud apparently splashed upon the trees in the vicinity would serve as an indication, when an explosion does take place the display must be a very fine one. The "Devil's Workshop" is a small steam spring issuing from a little cavern apparently 15 or 20 feet in depth horizontally, but constantly obscured by a great volume of vapor. Hollow, bubbling noises continually issue from it, which simulate, by aid of the cavern, the metrical clang and clash of great pieces of machinery, turning and splashing, accompanied by a recurring hiss of escaping steam. About 4 p. m. pistol-shots from the Mud Geyser summoned us to witness an explosion. The water had risen gradually until the smaller springs were submerged and the basin enlarged to its full dimensions. Near the center the geyser was boiling and bubbling actively, and soon spurted to a height of 5 or 6 feet, falling and rising again, and after about three minutes of excitement subsided, the water lowered, being gradually swallowed down the several orifices, and the discharge was over. The geyser has a period of about 4½ hours, and several of the subsequent eruptions were witnessed. None exceeded 10 or 15 feet in height. The force is evidently weakening, as indeed the large number of dead and dying thermal springs seen in other localities additionally testify. This geyser has been known in previous years to spout 50 and 75 feet. There is still, however, a wonderful amount of force at work, and in a marvelous variety of forms.

The fish taken from the river near camp were in appearance large and fine, weighing two pounds and upward; but out of the large number caught, all, with one exception, were affected by the worm mentioned by previous visitors and described by Professor Leidy. The appearance and health of the trout do not seem to be noticeably injured by them, but the presence of the worm in the flesh can almost invariably be detected from a slight protuberance or rounding-out on the sides. Laying this open, the worm is found, white, the size of a knitting-needle, and twisted in the flesh. We made no experiments to determine the flavor of these fish, although many of the men ate them heartily and pronounced them perfectly good. It is certainly most unfortunate that these fine fish should be so spoiled for the table. They abound in the lake and river, and, affording the finest sport, would be an immense attraction could they be used for food.

August 19.—Without moving camp, we rode 7 or 8 miles to a "ranch" in a grove on the west shore of the lake. From the Mud Geyser, the trail led through alternate forest and river side, with an occasional marsh, the landscape generally quiet and pastoral. Ascending upon a

high prairie point, the lake lay before us, a beautiful sheet of water, with deeply-indented shores, and the wooded mountains closing it in on all sides. We chartered a small center-board cat-rigged sail-boat, cleverly constructed by the owner of pine cut out of the forest with a whip-saw, and crossed to the east shore. The water appeared filled with a round greenish seed, probably of some aquatic plant, and little windrows of the same seed lay upon the beach, thrown up by the waves. Some trout were taken with a spoon on the way over, all wormy, and a squall or two gave variety to the sail and tested the weatherly qualities of the boat.

We passed the mouth of Pelican Creek, in the valley of which large numbers of thermal springs have been found, and landed near Steamboat Point, 7 miles from the starting-point. Two or three steam-vents were seen, and one of them on the farther side of the point has suggested the name. From a small aperture, colorless superheated steam escapes with a hiss and roar that indicate an excessive tension, and imitating precisely the blowing-off from a full boiler. Multitudes of grasshoppers, unwittingly encountering the steam, had met instant death.

From the projecting point, some 12 feet above the water, the finest fly-fishing was found. An arc of nearly 180° could be covered with the fly in from 6 to 10 feet of water, out into the lake as far as the skill of the fisherman would admit. The fish, though sometimes gorged with grasshoppers, would rise eagerly to the fly, and weighed from 1½ to 4 pounds and upward. The largest measured 20 inches in length. None of them could be eaten.

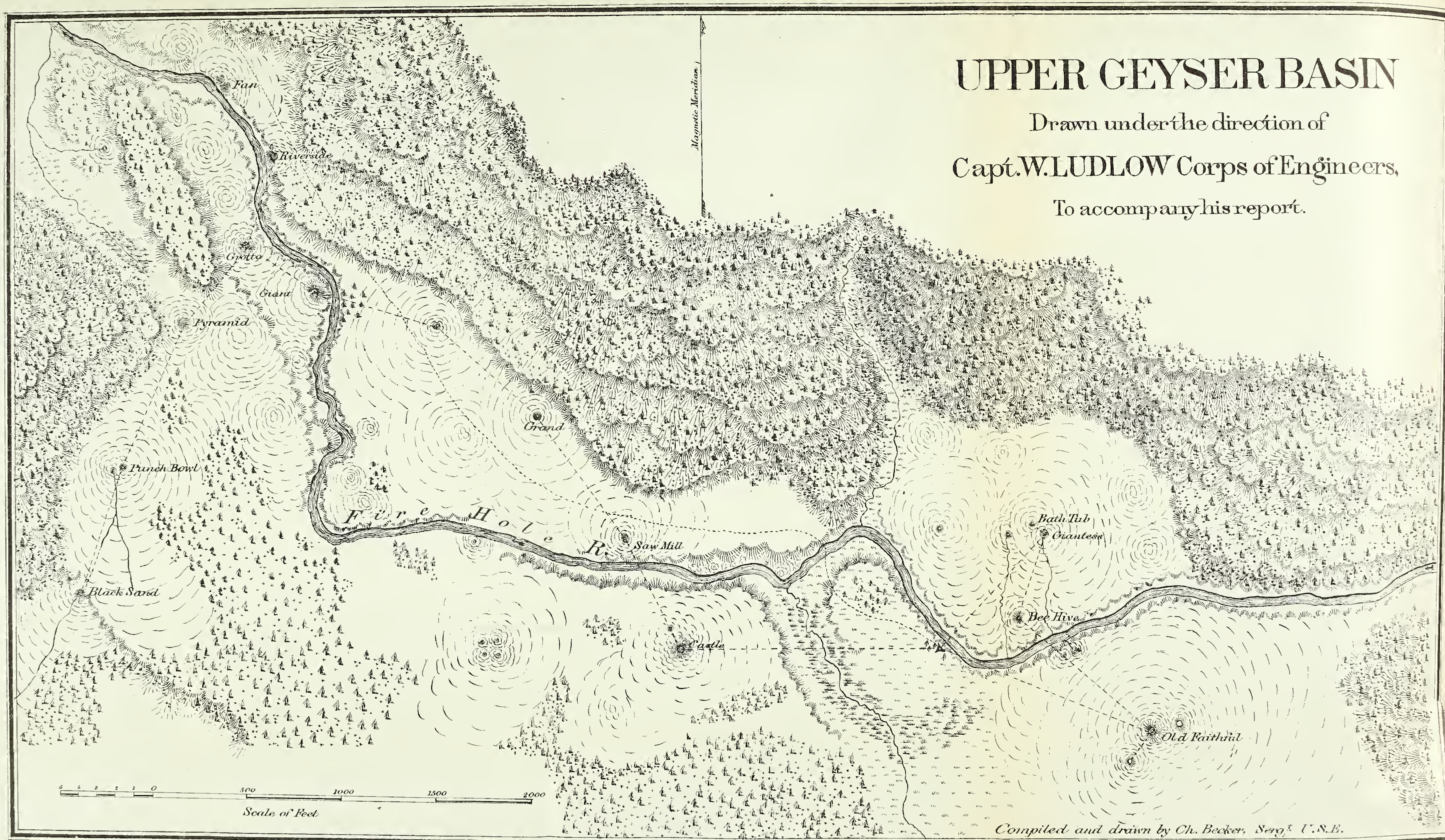
August 20.—The trail to the Great Geyser Basin breaks away from the vicinity of the Mud Geyser to the west and north over an open sage-brush prairie, gradually becoming more hilly, crosses Alum Creek near its head, and following up a small *coulé* with flowing water at 6 miles from camp, climbs a hill and enters a heavy forest richly grassed. The ascent through this forest to the summit of the divide between the Yellowstone and Madison Basins is very gentle from the east. Two or three groups of sulphur springs were passed on the way. The descent from the divide into Madison Valley is precipitous, winding down a drop of a thousand feet through fallen and burned timber, and over a rocky, bare, and stony soil destitute of grass. Reaching the border of the valley of the East Fork of Madison River, the trail winds along the foot-hills, to avoid an alkaline, boggy meadow, finally crosses the meadow and two or three alkaline brooks, in which the animals mired badly, and follows down the bank of the East Fork, which was forded two or three times. The stream is 10 to 20 feet wide and 2 or 3 feet deep; a clear, swift current and gravelly bottom, the water tepid and alkaline from the numerous hot springs which discharge into it. Camp was made in a grove of pine, after having traversed a pass between two hills which project into the Lower Geyser Basin. A small rill furnished a sufficient supply of good water, but the grazing was inferior. Several hot springs had been passed before reaching camp, and to the south the geysers appeared covering a large area. The distance traveled during the day was about twenty-six miles.

The upper valley of the Madison, including those of the forks, is quite barren and unattractive, owing probably to the action of the chemical hot springs which abound everywhere. The bordering hills are stony and bare, and at the time of our visit were covered with dead and burned timber. The landscape in consequence is uninviting, the grass poor, and good camping-places, such as can be made at almost any point in the Yellowstone Basin, are not to be found.

August 21.—The morning was devoted to the examination of the springs and geysers of the Lower Basin, which are very numerous, and cover a large extent of ground, the principal ones being about half a mile to the southward and eastward of camp. Minute descriptions of them have been published, and a detailed account is here unnecessary. Some are boiling, others spouting springs, the latter generally intermittent. On a high mound built by the geyser, we found a large pool about 25 by 15 feet, which was known to play, and the discharge of which we awaited. The water, of a deep azure hue and a surpassing clearness, was rising gradually but constantly to the level of its scalloped and ornamented rim, constantly becoming hotter, with bubbles of steam escaping more and more rapidly. Ebullition began near the middle, and the geyser finally commenced to spout, throwing the water about in all directions and to heights varying from 10 to 50 feet. The display continued for over an hour, and we left it playing, but with gradually-diminishing force. Meanwhile other smaller geysers in the vicinity played from time to time, all apparently independent of each other. The pools of all these, exhibiting every variety of form and ornamentation, possessed in common the beautiful azure tint and clearness of the water, contrasting finely with the light-gray hue of the silica deposited by them. The margins of all were incrusted with this in various forms of bead, coral, and sponge work, and wherever the geyser-water flowed silicious shale was deposited.

Passing over a low ridge, a few hundred yards to the southeast, we came upon the "Paint Pots." This singular phenomenon consists of a "pool" some 60 by 40 feet, with a raised margin of dry and cracked mud, within which numerous mud-puffs slowly rose and fell, some through the partially liquid mass, which again closed over them, others possessing a small crater of their own, to which additions were constantly making from the bursting of the sluggish bubbles. The pool displayed various colors, white, yellow, and red predominating, but shading into each other very beautifully through all the intermediate and combined tints. The clay was soft and smooth to the touch, with scarcely a trace of grit, and near where the bubbles emerged from below exceedingly hot.

Leaving these, and passing by many other springs and small geysers, we went down to the Fire Hole River, crossed it, and pushed on up the west bank toward the Upper Basin, wherein are situated the Grand Geysers. After some 2 or 3 miles of travel over fallen timber and through marsh and bog, we came upon some immense springs and pools, boiling violently and discharging a great amount of water into the river. These exhibited many hues of red, yellow, and green, from the presence of iron and vegetable growths; the pure geyser blue appearing where the spring was deepest and clearest. From the pools, we continued, passing many curious springs and small geysers, and then, crossing to the east bank, pushed rapidly on through a sort of cañon on the river, until at about 7 miles from camp, in the Lower Basin, we reached the lower end of the Upper, and were at once hurried across to the west bank again to examine the "Grotto," which began to play as we arrived. This geyser does not spout to any great height, 20 or 25 feet being the limit, but is beautiful and interesting from the shape of its crater, which, some 12 or 14 feet in height, is curved and convoluted into massive arches and exceedingly graceful forms. It played whenever we were by to see it, and evidently continues in operation for considerable periods, from the dimensions of the crater it has built. These craters are all constructed, by the geysers themselves, of the grayish-white silica, or geyserite, deposited by the cooling of the water; the process being


UPPER GEYSER BASIN
Drawn under the direction of
Capt. W. LUDLOW Corps of Engineers,
To accompany his report.
Magnetic Meridian
Fan
Riverside
Grotto
Giant
Pyramid
Grand
Punch Bowl
Fire Hole R.
Saw Mill
Black Sand
Castle
Bath Tub
Giantess
Bee Hive
Old Faithful
500
1000
1500
2000
Scale of Feet
Compiled and drawn by Ch. Becker, Sergt. U.S.E.

very gradual and slow. The water in all is of the same pure clear blue, without a trace of any impurity. The taste, when cool, is the flat, insipid one of distilled water.

Close by the "Grotto" stands the picturesque crater of the "Giant," or "Broken Horn," a geyser of the first class. From the aperture of this, large volumes of steam were escaping, and the water was boiling violently 8 or 10 feet below the surface, occasionally rising in huge spurts and splashing over, symptoms which led us to watch it unavailingly for an hour in hope of a discharge.

Meanwhile the pack-train had been making its way along the regular trail up the east bank, and, reaching the Upper Basin, camp was established in the center of the basin on the west bank of Fire Hole River, in a small group of trees, with a fairly good marsh in front for the cattle. We found the waters of the river cool and palatable, and sufficient wood for camping purposes at hand. At short range from camp, and in full view of it, were the first-class geysers named "Old Faithful," the "Bee Hive," the "Giantess," the "Grand," and the "Castle;" while the "Giant" and the "Grotto" were but a short distance farther down stream. Beside these, the "Pyramid" and "Punch Bowl," near the "Giant," could be easily seen. Almost as we reached the camp, "Old Faithful," which stands at the head of the valley overlooking it, and which has earned its name from the regularity of its discharges, gave us his first display. The time was noted and the second discharge awaited. An hour after, we walked over to the elevation which marked his crater, 400 yards from camp. In a few minutes, after some preliminary spurts and splashes, the geyser, emitting a deep roar which shook the ground, shot up a clear, straight shaft of water, which, with two or three rapid impulses, gained an altitude of over 100 feet; clouds of steam towering far above and drifting with the wind. For full five minutes, the superb column maintained its height, and then, with some unavailing efforts to check its fall, sank down, and was swallowed up in the crater. An examination of this followed. An immense quantity of water had been ejected, which, after bathing the crater and refilling the adjacent pools, flowed down the slopes and discharged by various channels into the river. The crater of "Faithful" is one of the most beautiful of all. The lips are molded and rounded into many artistic forms, beaded and pearled with opal, while closely adjoining are little terraced pools of the clearest azure-hued water, with scalloped and highly-ornamented borders. The wetted margins and floors of these pools were tinted with the most delicate shades of white, cream, brown, and gray, so soft and velvety it seemed as though a touch would soil them. The material, however, is the constant silica, of which also are composed the pretty pebbles which furnish an additional charm to the pools.

The only blemish on this artistic handiwork had been occasioned by the rude hand of man. The ornamental work about the crater and pools had been broken and defaced in the most prominent places by visitors, and the pebbles were inscribed in pencil with the names of great numbers of the most unimportant persons. Such practices should be stopped at once. The geysers are more than worthy of preservation. It is not only that they constitute a superb spectacle in themselves; they are likewise unique, both in performance and design. Nature, abandoning for the time all thoughts of utility, seems to have been amusing herself in this far-off and long-hidden corner of the world by devoting some of her grandest and most mysterious powers to the

production of forms of majesty and beauty such as man may not hope to rival.

The geysers, in the slow process of centuries probably, have built up miracles of art, of an enduring though brittle material, that can be ruined in five minutes by a vandal armed with an ax, and nearly all the craters show signs of the hopeless and unrestrained barbarity of many of their visitors. It cannot fail to fill the mind with indignation to see the utter ruthlessness of these sacrilegious invaders of nature's sanctuary. To procure a specimen of perhaps a pound weight, a hundred pounds have been shattered and destroyed, and always in those places where the most cunning art has been displayed, and the ruin produced is correspondingly great. Upon our arrival in the basin, we found several persons already encamped, and a whisky-trader snugly ensconced beneath his 'paulin, spread in the shelter of a thick pine. The visitors prowled about with shovel and ax, chopping and hacking and prying up great pieces of the most ornamental work they could find; women and men alike joining in the barbarous pastime.

With regard to the play of the geysers, our visit was well-timed. Just at twilight, the "Bee Hive," 400 feet distant, on the opposite bank of the river, gave an exhibition of its power. The crater is a small, conical, gray mound of silica, severely simple and unpretentious in appearance, with an aperture of some 18 inches, from which steam gently escapes. Near by is a small vent, which is the herald and precursor of its greater neighbor.

Before the "Bee Hive" plays, this vent commences to emit steam loudly, with occasional splashes of water. Soon the geyser begins to boil and steam, the water occasionally surging over. Suddenly comes a burst of 15 or 20 feet, and then almost instantly the slender shaft rises to a height of nearly 200 feet. So great is the impetus, and so slender the column, that the water, in its swift ascent, is nearly all dissolved into fine spray, which drifts off with the clouds of steam before the wind, to fall like rain. The play lasted about three minutes, and ceased as suddenly as it had commenced.

An hour and five minutes after his previous display, "Faithful" again reared his magnificent column, and during the night, whenever the roar was heard, we looked out from our tents at the grand sight, rendered more beautiful by moonlight. The intervals were exactly 65 minutes in every case.

August 22.—We were aroused at an early hour by the report that the "Bee Hive" was again about to play. This proved a false alarm, but sufficed to draw us across the river, which was some 25 feet wide and 1½ to 2 feet in depth, and while on the opposite bank we examined the huge pool of the "Giantess," which was known not to have played for some weeks, for symptoms of agitation. We found it full to the brim with beautifully clear water, of a deep blue, boiling gently, and giving out clouds of steam. It stands upon a hill of silica, 420 feet from the "Bee Hive" and 300 yards from camp.

While waiting for breakfast, attention was called to the Grand Geyser, half a mile below camp, on the east bank, which had begun to send out great volumes of steam. Hastily mounting the nearest horses, we hurried down to it. The Grand Geyser is double, the two orifices 15 or 20 feet apart. The down-stream one has a handsome crater, while the other has only an ornamental pool, several feet lower. It is from the pool, however, that the discharge takes place. Rising with rapidly-succeeding impulses, the column rushed to a height of some 80 feet, sustained itself for a few seconds, fell, rose again, and receded to its basin.

In a minute or two, it again shot to the same height, again faltered, rose, and subsided. Still a third effort was made and exhausted, and the waters receded until the empty basin was exposed to view, and could be examined with impunity. Meanwhile the neighboring geyser was splashing its waters in all directions, and discharging clouds of steam, while a steam-vent close at hand kept up a most outrageous roar. Though not so lofty a play as some observed by previous visitors, the exhibition was very fine; the swiftly successive pulses of water and steam breaking into beads and spray at intervals up the full height of the column, accompanied by vast clouds of vapor, and the mighty roar, combined to make an imposing and beautiful spectacle.

The surroundings of the "Grand" are the most ornate of all, and exhibit greater variety and beauty than any other.

The "Turban," which stands at the northern edge of the "pool," serves to distinguish the geyser. It is of singular form, highly ornamented, and I experienced almost a pang in becoming conscious of an apprehension that I should meet it again somewhere on exhibition. Some visitor, a little more enterprising than his predecessors, will be sure to detach it and carry it off. Shovel and ax had been busy with the geyser, and large quantities had been removed.

While returning to camp, the "Castle," on the west bank, was observed to be in agitation and giving out vast quantities of steam. A discharge soon took place, to a height of 10 or 15 feet only; but from the commanding position of the geyser and its handsome appearance, possessing, as it does, a high mound, richly decorated, and several apertures through which it plays at once, the sight is very fine. Several times during the morning it repeated its performance, rarely exceeding, however, 20 or 25 feet. After breakfast we returned to the "Giantess," which was evidently becoming more excited, and, while awaiting its discharge, examined the surroundings more closely.

The basin is some 25 by 16 feet and 25 or 30 feet in depth, with scalloped margin; 70 feet north of this stands a handsome boiling spring, which has built itself a sarcophagus 2½ or 3 feet in height, like a huge bath-tub, with richly ornamental borders. This operates in sympathy with the "Giantess;" is excited, and boils violently with her; and we afterward found it empty and desolate, upon the dissipation of her power.

About 11 o'clock, this, the greatest geyser, gave its first spout, and we continued watching its subsequent action until nearly 3 p. m. The water was expelled by a succession of violent splashes to a height of 15 to 50 feet, but without at first reaching a great altitude. With occasional lulls, the performance went on, the water sometimes being thrown 100 feet in the air. Large stones and stumps were cast into the basin and hurled instantly to a height of 200 feet, the high wind which prevailed at the time preventing the water and steam from attaining a similar elevation. The water fell occasionally, leaving the basin empty; and by standing on the windward side we could look down into it and see the large triangular-shaped vent at the bottom, whence issued the transparent steam. Again and again the geyser renewed its strength, sending out vast volumes of steam with a deafening roar that shook the whole valley, and occasionally snatching hold of a new reservoir of water and instantly ejecting it; each fresh access of wrath or travail being heralded by deep, mighty thuds, as though some vast machinery were at work beneath. The exhibition of enormous power wasted in these prolonged spasms of blind rage was both fascinating and terrible, and the imagination, powerfully stimulated in the presence of such strength and fury, could not

avoid imputing to the scene the attributes of gigantic passion and suffering. It seemed as though the geyser, maddened by some inexpressible and mysterious torment, were imprisoned beneath and gradually exhausting herself in unavailing struggles to escape it by bursting the bonds that held her, the paroxysms of efforts being alternated with intervals of stupor, again and again overcome by her still unabated rage.

During the afternoon, the "Bee Hive" again played, the high wind depressing its column below that of the previous discharge.

A party, about dark, came in from Virginia City. Following up the valley of the Madison River, they had brought two wagons without much difficulty through the Lower Basin, but were compelled to leave them a short distance above on account of the fallen timber and bog along the trail. The distance to the Upper Basin from Virginia City is 110 miles.

August 23.—All the first-class geysers had now been favorably seen, with the sole exception of the "Giant," toward whose picturesque crater we went, with the intention of devoting the day to it. The "Broken Horn" is a well-chosen and descriptive name, and worthy of being retained. The crater is a steeply conical mound of geyserite, 12 or 15 feet in height, tapering toward the summit, and having the west side broken down, or rather partly unconstructed. The geyser still boiled strongly, and we felt great hopes of seeing it play. Near by are the "Grotto," seen yesterday, and which played almost constantly during the day; the "Pyramid," a cone of silica 25 or 30 feet high, with steam slowly escaping from it, but its life now nearly extinct; the "Punch Bowl," and smaller ones. The last-named geyser played frequently during the day, some of its exhibitions being very fine. We waited the greater part of the day for the "Giant" to give us a display, but though evidently powerfully excited and from time to time arousing fresh hopes, to our great regret failed to do so. Returning toward camp, the "Grand" again gave indications of strong disturbance, and we remained there for an hour, but without result.

While waiting, we had additional evidence of the brutality of the average visitors, several of whom, of both sexes, were busily chopping and prying out the most characteristic and conspicuous ornamental work. An earnest remonstrance was followed by a sulky suspension of hostilities, which were, however, no doubt renewed as soon as we were out of sight.

The "Saw Mill," above the "Grand," is an interesting geyser. Its lively play, and its quick, energetic spouts of 25 or 30 feet in every direction, are very pleasing, and its borders abound in the pretty geyserite pebbles, some smooth, others ornamented, and others again resembling a rose-bud, with closely-folded leaves.

Recrossing to the west side of the river, a close examination was made of the "Castle:" it has quite a lofty mound, broad, handsomely terraced, and profusely decorated with scalloped pools and little upright pinnacles and towers. It plays with great frequency, though not to a height exceeding perhaps 40 feet; still its very frequent flow and almost constant escape of large quantities of steam, with its striking-looking and highly ornamented crater, constitute it properly a geyser of the first class. This, too, showed, and even in a greater degree than others, how greatly protection against vandalism is needed. From every part of the "Castle" pieces had been chopped, loosening quantities of the rock and threatening to ruin the construction. Two women, with tucked-up skirts and rubber shoes, armed, one with an ax, the other with a spade, were climbing about. Should this continue for another

year or two, the beauty of form and outline of the geyser-craters would be destroyed. It should be remembered that these craters were constructed with the greatest slowness by almost imperceptible additions, which can only be made by a discharge from the geyser; while the material, though hard, is very brittle and easily knocked to pieces. We got back to camp just in time to prevent the fall of an uplifted ax, which a woman was evidently about to bring straight down on the summit of the "Bee Hive," whose modest crater forms so strong a contrast to the grandeur of its play. Our shouts fortunately reached her just in time, and subsequent remonstrance induced her at any rate to postpone the attack.

Another party of four men came over in the afternoon from the lake. Including my party, there were now some thirty visitors in the basin.

August 24.—Broke camp for the return to Ellis. I should have liked to return by way of the Madison Valley, for the purpose of examining that route, which at present is the only practicable one for wagons into the park; but I had reason to believe that the Missouri River navigation would probably close about September 20, and the long journey of 375 miles back to Carroll had yet to be made, and a few days' delay at Ellis, in order to refit and procure fresh transportation, to be allowed for. We took the back trail to the Lower Basin, examining *en route* the Fan, Riverside, and Sentinel Geysers. The day was cold, dark, and wet, the air chill and raw. Below the Upper Basin we met three men going to the geysers, each of whom, I supposed, would carry off 20 pounds of specimens and destroy 500. The trail between the two basins is about the worst in the park, and stands in urgent need of improvement, which could readily be effected, and without the use of skilled labor. Timber, fallen and standing, could easily be chopped and thrown aside, and the marshy places in great part avoided by making the trail on higher ground along the foot-hills. Crossing the Lower Basin, which the rain had made miry, and passing our former camp, we continued up the valley of the East Fork, the principal features of which are alkaline marsh, dead timber, and little or no grass, the surrounding hills being equally uninteresting to the rapid traveler.

I was desirous, on the score of time, to take the trail direct from the East Fork to Gardiner's River Springs, but a brief examination convinced me that nothing would be gained, as it was obstructed with fallen timber. The ascent out of the Madison Valley to the divide was laboriously made, the rise being fully 1,000 feet, and the back trail down the Yellowstone slope pursued. The Sulphur Springs, three in number, were briefly examined *en route*. They exhibit considerable activity, though evidently waning in force. The jets of vapor deposit small cones of nearly pure sulphur.

Emerging from the timber, and soon after reaching the head of Alum Creek, we left the trail going on to the Mud Geyser, and inclining to the left crossed a range of prairie-hills, and followed down the left bank of Alum Creek until the main trail down the Yellowstone was reached. This was pursued for 2 or 3 miles farther, and camp made in a drenching rain on a small creek, which we named "Jay Creek," and near the point where the two trails from Cascade Creek had united coming up. We had traveled for eleven hours and made about 36 miles.

August 25.—Took the back trail over which the pack-train had traveled on the journey out, past our former camp of the 16th and 17th on Cascade Creek, and up the creek-valley. The day was very wet and cold, and desirous as I was of again looking at the Grand Cañon, I was un-

willing to impair my vivid recollection of it by seeing it for the last time deprived of its marvelous wealth and brilliancy of color.

As we neared the belt of hills stretching nearly east and west across the trail, and commenced to ascend the shoulder of one of them, we were greeted with a sharp burst of hail, followed by successive gusty showers. The rain made the mountain-trail a hard one, turning the rich, black mold in the narrow bridle-path to a slippery mud, and making the up and down grades equally severe on the animals. The trail gradually ascends from the head of Cascade Creek to the divide between two mountains, thence following partly the valley of another creek, which rises nearly at the summit of the divide, descends a long winding slope, with many fatiguing and unnecessary rises and falls, until the west part of Mount Washburne is reached. Ascending this rapidly but laboriously to the shoulder, we were in a few minutes enveloped in a blinding snow-storm from the west and north, which forbade another ascent to the summit of the mountain, and continued until we were about to descend from the Elephant's Back. The thermometer fell below freezing, the wind blowing in furious gusts, and the snow occasionally turning to hail, with frequent splashes of rain. As we were about leaving the Elephant's Back, half-frozen and entirely discontented with the weather, a change took place. A rift suddenly opened in the clouds to the northward, and rapidly widening disclosed the mountain-tops brilliantly white with fresh-fallen snow, which reflected the clear rays of the sun; the dense strata of clouds drifting black and heavy beneath; the sun soon after reached us with grateful warmth.

The trail winds rapidly down to Tower Creek, just before reaching which two deer were seen, the only game animals we encountered in the park. A number of trout were taken at the mouth of the creek, and we were much disappointed to find that out of twenty-five cooked for supper two certainly were affected by the worm previously mentioned. It has been hitherto stated, and generally believed, that the wormy trout were confined to the lake and river above the falls. It afterward appeared that one captured in Cottonwood Creek, between Ellis and Baker, and several from Deep Creek east of Baker, were affected in the same way. Camp was made at the former place on Meadow Brook, and rain came on again in the evening.

August 26.—A visit was paid to Baronet's Ranch, across the bridge, in the forks. We found there a large collection of specimens from Amethyst Mountain, on the east side of the river, a locality which we had not time to visit. The specimens were mainly impure amethysts and forms of quartz, chalcedony, &c.

The weather continued unpropitious as ever, and in a drenching rain the back trail up Meadow Brook was resumed. In such weather, the trail is difficult and in places not a little dangerous. It leads along and ascends slopes of clay which the rain makes exceedingly treacherous and slippery, where a misstep would precipitate a mule with its pack or a horse with its rider down several hundred feet. A great improvement could be made with comparatively little labor by widening the trail and placing rocks on its outer edge. Rain fell all day, with occasional intervals of sunshine; the trail over the broad rolling divide between the Yellowstone and Gardiner's River affording a good road, however, even in such weather. The Gardiner's River Falls were passed, and the long, sloping descent made into the valley, out of which we again climbed to the springs, just before reaching which camp was made. The rain lasted all night with great severity; the temperature steadily falling nearly to the freezing-point. Soon after our arrival, an ambulance from

Ellis reached the springs, bringing Major Benham and his wife, who were about to make a tour of the park.

August 27.—Leaving Lieutenant Thompson in charge of the party, I took the ambulance, and accompanied by Mr. Wood set out for Ellis, desiring to precede the party and gain time by having transportation ready to take us on to Carroll. The mountains and hills were covered with heavy snow, but two or three hundred feet above us. The roads were exceedingly muddy and slippery; fresh rain falling at intervals during the day. At the toll-house, a certified memorandum of the Government transportation taken over the road was given to the proprietors. The tolls charged each way were $5.50 for a six-mule team, $4 for a four-mule team, and $1 for a single animal.

Bottler's Ranch was reached at 5 p. m., and very good meals and lodging obtained. We observed a small herd of cattle near by, with which three young buffalo were apparently entirely domesticated.

I was informed that the gold-washings at Emigrant Gulch, adjoining the peak of the same name, were this year paying well; the owners taking out $10 to $25 per man, and the net profit on each laborer being $5 to $15 per day.

August 28.—Started at 7 a. m. The heavy rains had cleared up in a hard white frost. The Bottlers have about 90 acres under cultivation, irrigating from the mountains.

Under the bright sky, Emigrant Peak looked exceedingly handsome; the upper 2,000 feet covered with a broad mantle of new-fallen snow, and the air, washed clean of all impurities, brought out with exceeding clearness the noble outlines and rich coloring. The road out of the Yellowstone Valley up Trail Creek needs additional work upon it, side-cutting and bridging. That down Coal and Rocky Cañon Creek is capable still of great improvement. Ellis was reached at 2.30 p. m.

August 29.—Rain fell all day. The Gallatin Valley was a sea of mud.

August 30.—Rain continued throughout the day. At 2 p. m. Lieutenant Thompson, with the party and pack-train, arrived.

August 31.—Weather showed no signs of improving. The necessary transportation could not be procured at the post, and it became necessary to hire a citizen's team in Bozeman.

September 1.—Still raining. This prolonged continuance of wet was pronounced to be unparalleled in the valley.

September 2.—Still raining. Despairing of any cessation of bad weather, I determined to make a start and try and get over the ground if only a few miles a day. Accordingly pulled out of Ellis in the afternoon with a train consisting of a four-mule ambulance, a six-mule team, and a citizen's team, consisting of six mules, and a wheel-team of two broncos or Montana ponies, the eight hauling a wagon and a trail-wagon. This is the ordinary freight-wagon of the Territory. The trail is attached to the lead-wagon by a broad, short tongue, at the extremity of which an iron eye fits upon the pintle or trail-hook, projecting from the rear of the rear axle. Both wagons are provided with powerful brakes, which are set in descending hills. The two wagons can together carry over fair roads from 6,000 to 8,000 pounds. The escort consisted of two sergeants and eight men of the cavalry.

By 9 p. m. the train, with the greatest difficulty, had made about 6 miles only, and camp was pitched in Bridger Creek Valley. The trail-wagon had to be left for the night some 2 or 3 miles back. Unfortunately this wagon contained the greater part of our bedding and personal belongings, and, as the temperature was very low, water freezing in the buckets, the night was anything but a comfortable one.

September 3.—Sent back and brought up the trail, after which, with almost infinite labor, we made 4 miles and camped. Much of the difficulty of hauling over this Bridger Pass could be obviated by cutting and rough-bridging, with the labor of troops.

Three of the party came into camp late. They had been hunting in the pass; had seen a number of elk on Bridger Mountain, and killed two or three.

September 4.—Broke camp at 7, with the sun shining, and pulled up the long hill, the descent from which reaches Brackett's Creek. This hill is a plain illustration of the slight trouble required to avoid excessive labor. A road *around* this hill, nearly on a level grade, might easily be made. In fact, the road is there, except that in one place, for a hundred yards, the slope is so steep as to imperil the equilibrium of a heavily-loaded wagon. A half-day's work with fifty men would make it entirely practicable. From Brackett's Creek there is a road leading down it for a short distance; then north, up the valley of Shield's River, past the Three Peaks, to the headwaters of the South Fork of Musselshell. It was represented, however, that this road was marshy in places, and, with the immense amount of rain which had fallen, would probably be impassable. I concluded, therefore, to take in preference the more hilly route over which we had come from Baker. About dark, after 10 miles of very laborious pulling, camp was made on the north side of the mountains, at the intersection of two small streams flowing out of the pass.

September 5.—Pulled out at 6.30, and after great difficulty and with continual doubling of teams and dropping the trail-wagon, which had again to be brought up, we got clear of the foot-hills at the entrance of the pass. Crossing the creek, which flows from the westward out of Flathead Pass, and its broad meadow-valley, we continued past the camp of August 8, and over the rolling sage-brush prairie to Cottonwood Creek, where we camped, having made 16 miles. During the day three of the party ascended the mountains on the west of Bridger Pass, and obtained a superb view over the Gallatin Valley beyond.

September 6.—Broke camp at 7. Fair progress was made, but the effect of the wet weather was still evident in the lower places, and wherever a small creek crossed the road. Fourteen miles from Cottonwood Creek we passed Sixteen Mile Creek, and inclining eastward, and leaving the Baker road, made camp 3 miles farther on, at the head of the south fork of Deep Creek. There was but little wood in camp; the grass and water, however, being good.

September 7.—Taking Reynolds, the guide, I started on in advance of the train for the forks of the Musselshell, with the double object in view of intercepting the Carroll mail-stage at that point, with probable advices for me, and of obtaining, if possible, some additional, or at least fresh, transportation, the animals having been greatly pulled down by the severity of the work since leaving Ellis.

Leaving the head of Deep Creek, the trail crosses a divide 200 or 300 feet high, and strikes the head of the South Fork of the Musselshell, which it follows to the junction with the North Fork.

The route for 5 or 6 miles is rough and broken, but finally follows the creek, which flows gently in a wide, fairly-grassed valley, surrounded by mountains. Many hundreds of cattle were grazing in this valley, which is an excellent stock-range. The "Forks" were reached at noon, 30 miles from camp. Captain Ball's company of the Second Cavalry and Rawn's of the Seventh Infantry were in camp on the broad, level tongue of land in the angle of the two streams. This camp is just on the border of the Indian range; is well supplied with all the principal

requisites of wood, water, and forage; and would be an admirable location for a permanent post for the protection of the Carroll road and the thriving settlements to the westward. These districts are threatened almost every summer with forays by the Indians, from which garrisons far in their rear could scarcely avail to guard them. These hostile invasions are always sudden and generally unforeseen, and only the promptest movements of troops can be of effect. It is not difficult to see that such movements would be greatly expedited and their effect by so much increased by meeting the Indians at the very door, as it were, and punishing them there rather than by trusting to the uncertain chance of overtaking them after the depredations had been committed. The garrison and post of Camp Baker, for example, moved forward and established anew at the forks of the Musselshell, would make almost secure the whole country behind, and, in addition, would afford a most favorable point from which to send out scouts and reconnaissances, or, on occasion, to initiate a campaign into the Indian country. Another consideration would be that the farther east such a post was established the cheaper and easier it would be to supply.

September 8.—The train came in at 9 a. m., having camped for the night 5 or 6 miles back. I was fortunate enough, through the kindness of Lieutenant English, Seventh Infantry, to obtain the loan for two days of an additional six-mule team, with which at noon we pulled out on the Carroll road, in company with Captain Browning and Lieutenant Woodruff, Seventh Infantry, made the 20 miles to Hoppley's Hole, and camped by a spring just north of the road. Wood was obtained from the eastern margin of this broad and deep *coulé*, in which, however, the grass was poor and thin.

September 9.—Started at 7 a. m., in advance of the train, with Captain Browning and a small party, for Camp Lewis. Near the spring, in Judith Gap, a small detachment of Eighteenth Infantry men was in camp. Scattered herds of buffalo could be seen grazing on the prairie south of Snowy Mountains. Deviating to the right of the Carroll road, we kept along the foot-hills of the mountains, crossing two or three small streams, and finding the grass of the hill-slopes rich and luxuriant. An hour's halt for rest was made on Little Trout Creek, and, resuming the journey, a heavy, recently-made Indian trail was crossed, leading northward. Lewis was reached at 5.15 p. m., after a rapid ride of forty-five miles.

September 10.—The train came in at 2 p. m., having camped on Buffalo Creek the night before.

September 11.—Pulled out at 8 a. m., and in a couple of hours met the Carroll stage at Warm Spring Creek. I was informed that the steamer Josephine would probably leave Carroll on the 18th or 19th, but was likely to make another trip, certainly if the stage of the river would admit. Camp was made on Armell's Creek, 25 miles from Lewis, with excellent wood, water, and grass. Opposite camp, on the other side of the creek, was a plantation of wild hops in full bearing. Mr. Grinnell was exceedingly desirous of examining for fossils the lower extremity of the Judith Basin near the Musselshell River. As there was still a margin of seven or eight days, with the chance of a later trip of the boat, I determined to divide the party, sending a portion of it, under command of Lieutenant Thompson, to the mouth of the Judith River, while I should go on to Carroll, ascertain as exactly as possible the probabilities of a later boat, and send out word at what time the party should reassemble. Mr. Dana concluded to accompany me to Carroll; his engagements at the East not admitting of any further delay on his part.

The wagons were therefore reloaded with the view of sending one six-mule team and the greater part of the cavalry escort to the Judith.

September 12.—The six-mule team was loaded with fifteen days' rations; all superfluous baggage being loaded into the others. The supposed best route to the mouth of the Judith was to incline southwest from camp for a few miles, until the divide between Warm Spring and Armell's Creeks was reached, thence west and north to the head of Dog River, and along the divide between that and Judith River, through a certain pass in the Bad Lands, of which we had general information only, to Claggett's Ranch or Camp Cooke, at the mouth of the Judith. At 8.30 the load was completed, and the two parties separated; Mr. Dana and myself, with a sergeant and one man of the cavalry escort and a sergeant and four men of the engineer detachment, proceeding on the road to Carroll, while all the others started for the Judith. We reached Box Elder Station 9 miles from camp, the edge of the Bad Lands at 16 miles, and Crooked Creek at 32 miles.

The day had been very hot and dusty, and we found no water between Box Elder and Crooked Creek. The bed of the creek was absolutely dry, and the single pool near the road had been trampled into a thick mud by the thirsty animals unhitched from two mule-trains and one bull-train, which had halted for the night on the creek. We had brought no water with us, and the prospects of a camp were wholly uninviting. About a mile farther down the creek-bed I observed two or three cottonwood-trees, and an examination of the locality resulted in the pleasing discovery of three small but undisturbed pools of water, tepid and alkaline, but much better than none. The grass in the vicinity too, though exceedingly poor and thin, had not been grazed by the freight-trains. Numbers of antelope had been seen all day, and from the high ground on the edge of the Bad Lands small herds of buffalo dotted the broken landscape toward the river.

September 13.—Pulled out at 8 a. m. Crossed Little Crooked Creek, and soon after ascended upon the high, rolling prairie, winding over which the road eventually leads out upon a high, narrow ridge near the river, where, turning to the eastward, the steep descent of 900 feet is made into the river-valley, where Carroll is situated. It was ascertained that the boat would probably reach Carroll on the 19th, and leave next day.

There was a possibility that a later trip would be made; but, as this depended entirely upon the stage of water, which was very low and still falling, reliance could not be placed upon it. The week's heavy rains in the upper valleys had caused a rise of about 6 inches in the channel at Carroll, but this rise had been already exhausted, and more rain could hardly be looked for. I therefore dispatched a messenger to Lieutenant Thompson to be back in Carroll on the night of the 19th.

September 14.—Mr. Dana was desirous of examining the Little Rocky Mountains some 30 miles to the north and west, and we accordingly made preparations for a trip to them. The ambulance was placed in a Mackinac boat ready for transportation across the river in the morning.

September 15.—Crossed the river in the Mackinac, swimming the animals. The party consisted Mr. Dana and myself and four men; one driving a pair of mules in the ambulance, which carried the rations and scanty allowance of bedding. Some of the Carroll hunters at first wished to accompany us, but were afterward deterred by reports of Indians near the mountains. I did not altogether regret this; for a small party entirely under control might be safer than a larger one without discipline. In order to get the ambulance out of the boat, we dropped down stream a mile and a half to the "point" below on the north bank,

whence a hay-road led up the hill, climbing the 800 or 900 feet of ascent which was necessary to reach the prairie above, thence winding along narrow ridges formed by the deeply-penetrating *coulés* and ravines setting back from the river-valley. Reaching the prairie, the Little Rockies were in full view, and we traveled rapidly toward them over a dry, stony, nearly level road, with a brief halt for water at a pool in an unnamed creek-bed. Reaching the margin of the high prairie overlooking Little Rocky Creek, the descent appeared precipitous and the valley below difficult to travel. We therefore proceeded directly toward the mountains, and took our chance of finding water. Approaching within 3 or 4 miles, a very good camp for our small party was found near some springs. There was no wood, but we were fortunate enough to find a few pieces of drift brought down from the mountains during a freshet, and buffalo-chips were abundant. Two or three herds of buffalo were grazing within sight, gradually moving off as they became aware of our presence, and the antelope were more numerous than I had ever seen them. Soon after sunset, the harvest moon swung its broad disk above the eastern horizon, and flooded the yellow prairie with almost the light of day, shining brilliantly all night from a cloudless sky. The air was still, and the temperature mild and pleasant. About midnight, the snorting of the horses aroused me, and I found the men all up to keep the buffalo, which surrounded the camp, from coming so near as to stampede our cattle. They were approaching us to get water from the springs upon which we were encamped. The animals loomed up huge and black in contrast with the yellow prairie, and were evidently in great numbers, as their deep rattling snorts and snuffles could be heard in all directions.

In the gray light of early dawn, an antelope, attracted by the white cover of the ambulance, walked nearly into camp, and furnished an excellent breakfast. It was a barren doe, very fat and tender, with small horns, an inch or two in length.

September 16.—Mr. Dana spent the day exploring and examining the mountains. Camp was broken at 8 with the intention of finding another farther east in a sort of bay in the south side of the range, where wood would be more convenient, and which should offer better protection in case the Indians should discover us.

The presence of buffalo in such great numbers, and the known propinquity of a large Indian camp some 25 or 30 miles to the eastward, on Pouchette Creek, induced me to believe that a more concealed camp would be much safer. The party was so small that it would be just as well to remain undiscovered. Entering the valley, it was found full of buffalo and antelope. The adjacent *coulés* and ravines were thoroughly examined for water without success, and I finally concluded to return to last night's camp. This is ordinarily an injudicious thing to do; but the quiet demeanor of the buffalo induced me to believe that they had not recently been hunted. Sending the ambulance back to camp, I took one man, and entered a pass behind the prominent mountain, where a well-worn game-trail furnished a good path. The mountains are well wooded and some 1,200 or 1,500 feet in height, apparently destitute of running water at this season. At a narrow place in the trail, a buffalo was encountered, who, after an instant's halt, uttered a frightened snort, and whirling his huge bulk around with ludicrous suddenness, set off at full speed. A few deer were seen, but no elk or sign of any. The mountains, in fact, seem to be too destitute of water to abound in the ordinary game. Emerging from the pass directly north of and in view of camp, the bed of the stream which supplied the springs below was found to be dry and stony. High up on the mountain-slopes a herd of buffalo were grazing, and Mr. Dana was distinguished approaching them with his

carbine. His shots killed one, and started the herd at headlong speed down the mountain. Hastily concealing ourselves in the bed of the stream, the herd swept past, losing two more of their number. I endeavored to overtake on horseback a calf, the mother of which had been killed, but my horse developed no great amount of speed, and the calf certainly did, skipping away from me with the utmost agility. We returned to camp and had a quiet night, though unpleasantly cold without tents, water freezing in the buckets.

September 17.—We had seen all that was necessary of the Little Rockies, and had more game than could be carried in; a prolonged stay might be attended with serious consequences, and camp was therefore broken at 8 for the return to Carroll. Steering by compass, we had proceeded for a couple of hours, when we saw half a mile ahead three men engaged in skinning a buffalo. Observing us, they mounted and started off, but soon halted and began to approach us. They proved to be Indians, a small hunting-party from the large camp, and got us to understand that they wanted to go in to Carroll with us as soon as they could dispose of the buffalo they were occupied with and another farther on. Though not anxious for their society, I assented, intending, in case of the appearance of a large party, and having any trouble with them, to hold the three as a sort of hostage. They worked with great earnestness and skill; and having loaded three ponies with beef in a very short space of time, two of them joined us. The headman pointed northeast, to where he said were forty-five lodges of his people. He denied being a Sioux, but spoke the language too well to be anything else. Approaching the river opposite Carroll, the two Indians wanted Mr. Dana and myself to go directly down the bluff to the river with them; but as my rifle had become disabled by an accident, and the pistol cartridges were exhausted, their offer was declined. One of them wished to assure me that he was unarmed, and throwing back his blanket showed an empty pistol-holster, and said he had lost it running buffalo. The same movement, however, exhibited the handle of a pistol on the other side. Apparently disgusted at our refusal, they plunged down the hill out of sight, and eventually reached town first.

September 18.—Crossed the ambulance back to Carroll. The steamer Josephine was looked for hourly during the day.

September 19.—At 2 p. m., Lieutenant Thompson, Mr. Wood, and the wagon arrived, and a few hours later Messrs. Grinnell, Ludlow, and Reynolds reached town in a small Mackinac, with which they had descended the river from the Judith.

A march of 44 miles in two days—September 12 and 13—had taken the party from the camp on Armell's Creek to the mouth of the Judith, where they remained two days, and returned to Carroll in four days. The lower portion of the Judith Basin is largely occupied by Mauvaises Terres, precipitous and forbidding, and very difficult to travel. A few interesting fossils were found; but the extent of the field and the limited time available prevented thorough search. A large camp of Gros Ventres was in the basin, intending to winter there, and game was scarce. At 5 p. m. the Josephine reached Carroll and discharged.

September 20.—Boat took on 60 tons of freight, and left at 4.30 p. m. Lieutenant Thompson was instructed to take the cavalry escort and transportation to Ellis and to return to Saint Paul via the Union Pacific.

The subsequent journey down the river was uneventful. The stream was very low, with only 18 inches of water on Buffalo Rapids, and we were frequently aground. When within 15 or 20 miles of Buford, we met the Key West and exchanged freights; the Josephine returning to Carroll to make one more trip.

September 26.—We left Buford on the Key West at 8 a. m., reaching Bismarck on the 29th, and Saint Paul October 2.

Thus terminated this most interesting trip, which had covered, by rail, water, and on horseback, thirty-three hundred miles of travel in ninety-three days, through every variety of landscape, from the most forbidding to the grandest and most picturesque.

I beg leave to add the following suggestions relative to the National Park. The main points are such as would present themselves to any visitor capable of appreciating the wonders of the park, and have been in some cases anticipated in the remarks and recommendations of previous visitors. Nevertheless, a repetition of them can do no harm, and will at least show what the concurrent testimony on the subject is.

Congress, by an act approved March 1, 1872, (sections 2474 and 2475, Revised Statutes, appended hereto,) set aside the area therein defined (and which intended to include all the more remarkable objects and scenery) as a national domain, and consecrated it to the enjoyment and improvement of all mankind. For this purpose, the park was placed under the control of the Secretary of the Interior; but, unfortunately, the act provides no further practical measures for its improvement than authorizing the making of small temporary leases (the revenues from which should be devoted to the proper management and improvement of the park) and the promulgation of regulations mainly looking to the preservation of the game. I am not informed as to whether any such leases have been made; but it is certain that no expenditures have been made for the improvement of the park, nor even for its proper protection. Of the preservation of the game I will mention some facts further on. The park remains in the same wild, secluded condition in which it was discovered, a few squatters and hunters inhabiting it. The number of visitors is not great, but is yearly increasing, and is mainly made up from the inhabitants of the Montana towns. Until some railroad facilities shall make the journey less expensive and fatiguing, the people at large can hardly avail themselves of the "pleasuring ground" so provided. Meanwhile, however, those who from propinquity are able to do so are entering upon the possession of their privileges, and abusing them by the wanton destruction of what was intended to be for the edification of all.

The treasures of art and beauty, cunningly contrived by the hand of nature, are in process of removal to territorial homesteads, and the proportion of material destroyed to that carried off is as ten to one. Hunters have for years devoted themselves to the slaughter of the game, until within the limits of the park it is hardly to be found. I was credibly informed by people on the spot, and personally cognizant of the facts, that during the winter of 1874 and 1875, at which season the heavy snows render the elk an easy prey, no less than from 1,500 to 2,000 of these, the largest and finest game animals in the country, were thus destroyed within a radius of 15 miles of the Mammoth Springs. From this large number, representing an immense supply of the best food, the skins only were taken, netting to the hunter some $2.50 or $3 apiece, the frozen carcasses being left in the snow to feed the wolves or to decay in the spring. A continuance of this wholesale and wasteful butchery can have but one effect, viz, the extermination of the animal, and that, too, from the very region where he has a right to expect protection, and where his frequent inoffensive presence would give the greatest pleasure to the greatest number.

The cure for these unlawful practices and undoubted evils can only be found in a thorough mounted police of the park. In the absence of any legislative provision for this, recourse can most readily be had to

the already-existing facilities afforded by the presence of troops in the vicinity and by the transfer of the park to the control of the War Department. Troops should be stationed to act as guards at the lake, the Mammoth Springs, and especially in the Geyser Basin. A couple of signal-sergeants might profitably be employed in keeping meteorological and geyser records, which would be of great interest and value.

In time, with faithful supervision, the park could easily be made self-supporting. Franchises and leases will be valuable, and, properly administered, would furnish a revenue sufficient to proceed gradually with all the improvements required. But meanwhile, and before any improvements can be judiciously undertaken, an indispensable preliminary would be a thorough and accurate topographical survey, which, having been completed, would serve to indicate where roads and bridle-paths could best be opened or most improved. The boundaries of the park could at the same time be run and laid down upon the ground.

For this a small annual appropriation of from $8,000 to $10,000 should be made, and the survey might properly be under the charge of an engineer officer, who, while making his survey and map, might at the same time be turning his attention and devoting, perhaps, a certain sum to the selection and construction of better routes of travel. While it would not be possible at once to make the park practicable for vehicles, the pack-trails could be vastly improved at slight expense, the survey indicating the best routes. An observatory on Mount Washburne, with a wire to Bozeman, could be constructed cheaply, and furnish a starting-point whence all the higher peaks, and from them the intervening country, could be mapped. Rough bridges could be constructed where needed, and the worst portion of the trail corduroyed. This preliminary work accomplished, (and about two seasons' work would be required for it, the yearly appropriation being continued,) the roads could by degrees be made practicable for wagons and carriages. Lodging-places could be constructed at the Mammoth Springs, the bridge, the falls, the lake, and the geyser-basins, for the accommodation of visitors; and these, after the construction by the engineer officer, should be under the charge of an officer detailed to make constant inspections of them and of the detachments doing guard and police duty in the park. Visitors should be forbidden to kill any game. The hunters should have their arms and spoils confiscated, besides being liable to prosecution.

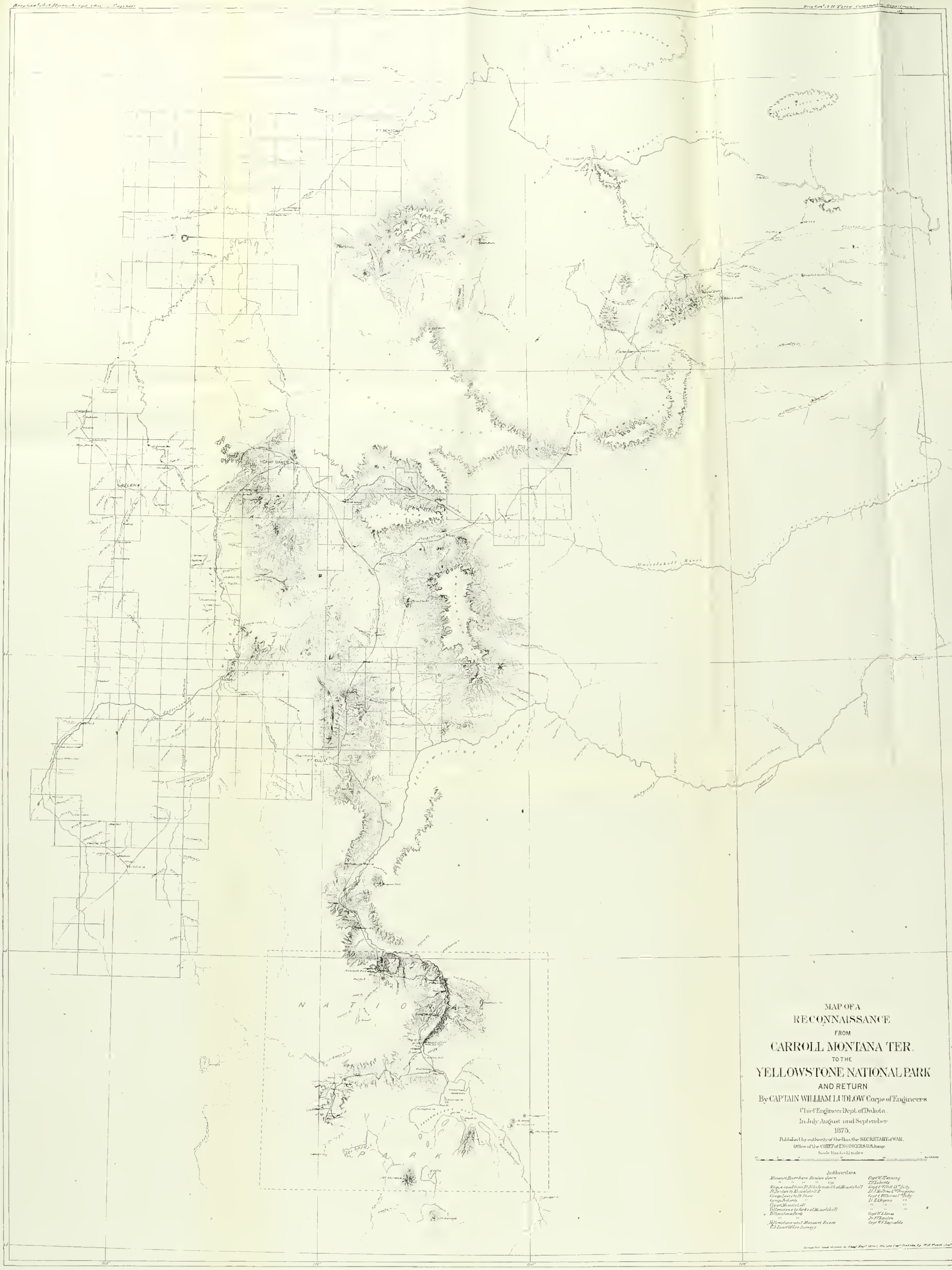
For the accomplishment of these purposes, it would certainly be most convenient and expedient to take advantage of the presence and organization of the military, and to intrust the care of the park, at least temporarily, to the War Department; at least until such time as a civilian superintendent, living in the park, with a body of mounted police under his orders, should suffice for its protection.

The day will come, and it cannot be far distant, when this most interesting region, crowded with marvels and adorned with the most superb scenery, will be rendered accessible to all; and then, thronged with visitors from all over the world, it will be what nature and Congress, for once working together in unison, have declared it should be, a national park.

Respectfully submitted.

WILLIAM LUDLOW,
Captain Corps of Engineers, U. S. A.,
Chief Engineer Department of Dakota.

The ASSISTANT ADJUTANT-GENERAL,
Department of Dakota, Saint Paul, Minn.



FT. BENTON
CAMP BAKER
HELENA
FT. ELLIS
NATIONAL PARK
MAP OF A
RECONNAISSANCE
FROM
CARROLL MONTANA TER.
TO THE
YELLOWSTONE NATIONAL PARK
AND RETURN
By CAPTAIN WILLIAM LUDLOW Corps of Engineers
Chief Engineer Dept. of Dakota.
In July August and September
1875.
Published by authority of the Hon. the SECRETARY of WAR,
Office of the CHIEF of ENGINEERS U.S. Army.
Authorities

ACT APPROVED MARCH 1, 1872.

(*Revised Statutes of the United States, sections* 2474 *and* 2475.)

SEC. 2474. The tract of land in the Territories of Montana and Wyoming, lying near the headwaters of the Yellowstone River, and described as follows, to wit: Commencing at the junction of Gardiner's River with the Yellowstone River, and running east to the meridian, passing ten miles east of the most eastern point of the Yellowstone Lake; thence south along said meridian to the parallel of latitude passing ten miles south of the most southern point of Yellowstone Lake; thence west along said parallel to the meridian passing fifteen miles west of the most western point of Madison Lake; thence north along said meridian to the latitude of the junction of the Yellowstone and Gardiner's Rivers; thence east to the place of beginning, is reserved and withdrawn from settlement, occupancy, or sale under the laws of the United States, and dedicated and set apart as a public park or pleasuring ground for the benefit and enjoyment of the people; and all persons who locate or settle upon, or occupy any part of the land thus set apart as a public park, except as provided in the following section, shall be considered trespassers and removed therefrom.

SEC. 2475. Such public park shall be under the exclusive control of the Secretary of the Interior, whose duty it shall be, as soon as practicable, to make and publish such regulations as he may deem necessary or proper for the care and management of the same. Such regulations shall provide for the preservation from injury or spoliation of all timber, mineral deposits, natural curiosities, or wonders within the park, and their retention in their natural condition. The Secretary may, in his discretion, grant leases for building purposes, for terms not exceeding ten years, of small parcels of ground, at such places in the park as may require the erection of buildings for the accommodation of visitors; all of the proceeds of such leases, and all other revenues that may be derived from any source connected with the park to be expended under his direction in the management of the same, and the construction of roads and bridle-paths therein. He shall provide against the wanton destruction of the fish and game found within the park, and against their capture or destruction for the purpose of merchandise or profit. He shall also cause all persons trespassing upon the same to be removed therefrom, and generally is authorized to take all such measures as may be necessary or proper to fully carry out the objects and purposes of this section.

ASTRONOMICAL OBSERVATIONS FOR TIME AND LATITUDE AT CARROLL, CAMP LEWIS, AND CAMP BAKER.

Observation for time.

Station Carroll, Montana.—Date, July 12, 1875.—Object observed, Arcturus.—Sextant, Spencer Browning. 6536.—Chronometer, Bond & Son, 202.—Index error, −60″.—Observer, Wood.—Computer, Wood.

Double altitudes observed.	Corresponding times.
° ′ ″	h. m. s.
74 50 00	18 54 25.
	54 55.5
	55 26.5
	55 57.
	56 26.5
	56 58.5
73 50 00	18 57 29.
74 20 00	18 55 56.9

		° ′ ″
Refraction = R	=	1 10
Parallax = P	=	
Semi-diam. = Sd	=	
R, P, and Sd	=	1 10
Observed 2 alt.	=	74 20 00
Index error	=	− 1 00
2 alt. corrected	=	74 19 00
Altitude	=	37 09 30
R, P, and Sd	=	− 1 10
True alt. = A	=	37 08 20
log cos L	=	9.8289930
log sin △	=	9.9734435
log cos L sin △	=	9.8024365

		° ′ ″
Latitude = L	=	47 35 00
N. polar dist. = △	=	70 10 00
True altitude = A	=	37 08 20
2 m = L + △ + A	=	154 53 20
m	=	77 26 40
m—A	=	40 18 20
log cos m	=	9.3372319
log sin (m—A)	=	9.8108128
log cos m sin (m—A)	=	19.1480447
log cos L sin △	=	9.8024365
log sin² ½ p	=	19.3456082
log sin ½ p	=	9.6728041
		° ′ ″
½ p	=	28 05 02
p in arc	=	56 10 04
		h. m. s.
p in time	=	3 44 40.27
∗Æ	=	14 09 59.5
Equation of time	=	
True time	=	17 54 39.77
Time by chron.	=	18 55 56.87
Chron. fast	=	1 01 17.1

Determination of the latitude by observed double altitudes of Polaris off the meridian.

Station, Carroll, Montana.—Date, July 12, 1875.—Sextant, Spencer Browning.—Index error, − 60″.—Chronometer, Bond & Son, 202.—Observer, Wood.—Computer, Wood.

Observed double altitudes. °	′	″	Corresponding times. h.	m.	s.
94	32	00	19	19	43.
	32	20		20	36.
	33	00		21	20.
	33	10		22	07.
	33	50		22	42. 5
	34	40		23	45. 5
94	35	20	19	24	45. 5
94	33	29	19	22	08. 5
	1	00			
94	32	29			
47	16	14. 5			
		50. 0			
47	15	24. 5			

		°	′	″
log cos p	= 9. 3515862			
log Δ	= 3. 6897527			
log Δ cos p	= 3. 0413389			
	= 1099″. 9			
1st term	=		18	19. 9
Alt. = A	=	47	15	24. 5
2d term	=	47	33	44. 4
Latitude	=			59. 7
		47	34	44. 1

log sin p	9. 98875
log Δ	3. 68975
log Δ sin p	3. 67850
log (Δ sin p)^2	7. 35700
log a	3. 38454
log tan A	0. 03425
log 2d term	1. 77579
2d term	59″. 7

Refraction			−50″
Chron. correction	1h	01m	17s.1
Dec	88°	38′	25″
Δ			4895″
	h.	m.	s.
Æ Polaris	1	12	47. 7
Sid. time at mean noon at this station			
Sid. interval from mean time of culmination			
Retardation of mean on sidereal time			
Mean time of culmination of star			
Error of chron. at time of observation	1	01	17. 1
Time by chron. of culmination	2	14	04. 8
Sid. time of observation	19	22	08. 5
Hour-angle, p, in mean time	6	51	56. 3
Sidereal equivalents in arc	102°	59′	05″
p in arc			

Determination of latitude by circum-meridian altitudes.

Station, Carroll, Montana.—Date, September 20, 1875.—Object observed, ☉.—Sextant, Spencer Browning, 6536.—Index error, $-1' 15''$.—Chronometer, Arnold & Dent, 1362.—Observer, Wood.—Computer, Wood.—Bar., $27^{in}.61$.—Ther., 61°.

Times of observation by chronometer.	Meridian distance $= p$.	$\frac{2 \sin^2 \frac{1}{2} p}{\sin 1''} = k$.	$\frac{\cos l \cos D}{\cos a}$.	Reduced to meridian in arc $= x$.	Observed 2 circum-meridian altitudes.	Observed altitudes, corrected for index error.	True altitudes $= a$.	True meridian altitudes deduced $= a + x = A$.	Latitude deduced $= 90° + D - A$.
h. m. s.	′ ″	″		″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
12 50 43.	4 42.	43	Constant multiplier, .93	40	86 24 50	43 11 47	43 26 56	43 27 36	47 34 51
51 12.	4 13.	35		33	87 29 00	43 52	27 05	27 38	49
51 42. 5	3 42. 5	27		25	86 25 30	12 07	27 16	27 41	46
52 18. 5	3 06. 5	19		18	87 29 50	44 17	27 30	27 48	39
52 47.	2 38.	14		13	86 25 50	12 17	27 26	27 39	48
53 14. 5	2 10. 5	9		9	87 30 00	44 22	27 35	27 44	43
53 39.	1 46.	6		6	86 25 40	12 12	27 21	27 27	60
54 15.	1 10.	3		3	87 30 10	44 27	24 40	27 43	44
54 53. 5	31. 5	0		0	86 26 00	12 22	27 31	27 31	56
55 27.	02.	0		0	87 30 00	44 22	27 35	27 35	52
55 50.	25.	0		0	86 25 50	12 17	27 26	27 26	61
56 19. 5	54. 5	2		2	87 29 50	44 17	27 30	27 32	55
56 46.	1 21.	4		4	86 25 40	12 12	27 21	27 25	62
57 24. 5	2 00.	8		8	87 29 50	44 17	27 30	27 38	49
57 57. 5	2 32. 5	13		12	86 25 30	12 07	27 16	27 28	59
58 25. 5	3 00. 5	18		17	87 29 30	44 07	27 20	27 37	50
58 46. 5	3 21. 5	22		21	86 25 20	12 02	27 11	27 32	55
59 20.	3 55.	30		28	87 29 20	44 02	27 15	27 43	44
12 59 49.	4 24.	38		35	86 25 00	43 11 52	43 27 01	43 27 36	47 34 51
Mean latitude									47 34 51

		° ′ ″		
App. Lat. $= l$	=	47 35	cos 9.82899	
Dec.	=	1 02 27. 3	cos 9.99993	
a	=	43 28 10.	cos 0.13922	
			9.96814	

	h. m. s.
Chronometer correction	—1 02 04. 16
Equation of time	+ 6 38. 92
	— 55 25. 24

	′ ″	′ ″
Semi-diameter	+15 58. 5	— 15 58. 5
Refraction	55. 9	— 54. 9
Parallax	+ 6. 3	+ 6. 3
	+15 09.	— 16 47.

Determination of the time by observed equal altitudes of the sun's limb.

TO CORRECT THE CHRONOMETER AT NOON.

Station, Carroll, Montana.—Date, September 20, 1875.—Sextant, Spencer Browning, 6536.—Chronometer, Arnold & Dent, 1362.—Observer, Wood.—Computer, Wood.

Observed double altitude.	Corresponding times. A. M. = t	Corresponding times. P. M. = t'	$t-t'$ = elapsed time.	Equation of equal altitudes = x.	Chron. fast of mean time at appt. noon by each pair of equal altitudes.
° ′ ″	*h. m. s.*	*h. m. s.*	*h. m.*	*s.*	*h. m. s.*
72 10 00	10 51 40. 5	2 58 34. 5			
	52 04. 5	58 10. 5			
	52 29.	57 47.			
	52 51. 5	57 23.			
	53 14. 5	57 00.			
	53 38.	56 37.			
	54 03.	56 1[illegible]. 5	4 2	+16. 80	1 02 04. 16
	54 27.	55 50.			
	54 50. 5	55 27. 5			
	55 14. 5	55 04.			
	55 38. 5	54 42.			
	56 02.	54 16. 5			
73 10 00	10 56 26. 5	2 53 53.			

$T = 4^h\ 2^m$
$\delta = -58''.33$
$L = 47°\ 35'$
1st term $= +17^s.04$
2d term $= -\ 0^s.24$

$x = +16^s.8 =$ equation of equal altitudes.

log A (page 164) $= -9.4263$
log δ $= -1.7659$
log tan $= 0.0392$
$= +1.2314$

log B $= +9.3627$
log δ $= -1.7659$
log tan D $= +8.2597$
$= -9.3883$

h.	*m.*	*s.*	
10	54	03. 08	
14	56	13. 81	
25	50	16. 89	
12	55	08. 44	
		13. 80	
12	55	25. 24	= eq. of time.
11	53	21. 08	
1	02	04. 16	

Observation for time.

Station, Camp Lewis, Montana.—Date, July 25, 1875.—Object observed, Altair.—Ref. Circle, Gambay and Son, 212.—Chronometer, Bond & Son, 202.—Observer, Wood.—Computer, Wood.—Bar., 25in.95.—Ther., 58°.

Double altitudes observed.

°	′	″
720	00	00
67	58	20
787	58	20
78	47	50

Corresponding times.

h.	m.	s.
18	11	45
	12	30.5
	13	32
	14	28.5
	15	20.
	15	55.5
	16	34.5
	17	38.5
	18	31.5
18	19	20.5
18	15	33.6

		°	′	″
Refraction = R	=			63
Parallax = P	=			
Semi-diam. = Sd	=			
R, P, and Sd	=			
Observed 2 alt.	=	78	47	50
Index error	=			
2 alt. corrected	=	78	47	50
Altitude	=	39	23	55
R, P, and Sd	=		1	03
True alt. = A	=	39	22	52
log cos L	=	9.8332861		
log sin Δ	=	9.9951575		
log cos L sin Δ	=	9.8284436		

		°	′	″
Latitude = L	=	47	03	40
N. polar dist. = Δ	=	81	27	35
True altitude = A	=	39	22	52
$2m = L + \Delta + A$	=	167	54	07
m	=	83	57	03
m—A	=	44	34	11
log cos m	=	9.0227658		
log sin (m—A)	=	9.8461980		
log cos m sin (m—A)	=	18.8689647		
log cos L sin Δ	=	9.8284436		
log $\sin^2 \frac{1}{2} p$	=	19.0405211		
log $\sin \frac{1}{2} p$	=	9.5202605		
		°	′	″
$\frac{1}{2} p$	=	19	20	58
p in arc	=	38	41	56
		h.	m.	s.
p in time	=	2	35	47.7
⁎ Æ	=	19	44	43.8
Equation of time	=			
True time	=	17	09	56.1
Time by chron.	=	18	15	33.6
Chron. fast	=	1	05	37.5

Observation for time.

Station, Camp Lewis, Montana.—Date, July 25, 1875.—Object observed, Arcturus.—Ref. Circle, Gambay & Son, 212.—Chronometer, Bond & Son, 202.—Observer, Wood.—Computer, Wood.—Bar., 25in.95. Ther., 58°.

Double altitudes observed.

°	′	″
720	00	00
212	32	10
932	32	10
93	15	13

Corresponding times.

h.	m.	s.
17	56	00.
	59	00.
	59	54.5
18	01	19.5
	02	21.5
	03	14.
	04	13.5
	05	01.
	06	09.
18	07	02.
18	02	25.5

		°	′	″
R fraction = R	=			50
Parallax = P	=			
Semi-diam. = Sd	=			
R, P, and Sd	=			
Observed 2d alt	=	93	15	13
Index error	=			—
2 alt. corrected	=	93	15	13
Altitude	=	46	37	36
R, P, and Sd	=			50
True alt. = A	=	46	36	46
log cos L	=	9.8332861		
log sin Δ	=	9.9734435		
log cos L sin Δ	=	9.8067296		

		°	′	″
Latitude = L	=	47	03	40
N. polar dis. = Δ	=	70	10	00
True altitude = A	=	46	36	46
$2m = L + \Delta + A$	=	163	50	26
m	=	81	55	13
m — A	=	35	18	27
log cos m	=	9.1478335		
log sin (m — A)	=	9.7619011		
log cos m sin (m — A)	=	18.9097346		
log cos L sin Δ	=	9.8067296		
log $\sin^2 \frac{1}{2} p$	=	19.1030050		
log $\sin \frac{1}{2} p$	=	9.5515025		
		°	′	″
$\frac{1}{2} p$	=	20	51	29
p in arc	=	41	42	54
		h.	m.	s.
p in time	=	2	46	51.6
⁎ Æ	=	14	09	59.2
Equation of time	=			
True time	=	16	56	50.8
Time by chron.	=	18	02	25.5
Chron. fast	=	1	05	34.7

Determination of the latitude by observed double altitudes of Polaris off the meridian.

Station, Camp Lewis, Montana.—Date, July 25, 1875.—Ref. Circle, Gambay & Son, 212.—Chronometer, Bond & Son, 202.—Observer, Wood.—Computer, Wood.—Bar, 25in.95.—Ther., 58°.

Observed double altitudes.			Corresponding times.		
°	′	″	h.	m.	s.
			18	50	45.5
				51	37.
				52	44.5
				53	53.5
				54	42.
			19	00	36.
				01	30.5
				02	30.5
720	00	00		03	19.5
211	55	00	19	04	08.5
931	55	00	18	57	34.75
93	11	30			
46	35	45			
		50			
46	34	55			

log cos p	=	9.5393086		
log Δ	=	3.6895752		
log Δ cos p	=	3.2288838		
	=	1694″		
		°	′	″
1st term	=		28	14
Alt. = A	=	46	34	55
2d term	=			54
Latitude	=	47	04	03

log sin p	9.97228
log Δ	3.68958
log Δ sin p	3.66186
log (Δ sin p)^2	7.32372
log a	4.38454
log tan A	0.02399
log 2d term	1.73225
2d term	″54

Refraction			50″
Chron. correction	1h	05m	36s.1
Dec	88°	38′	27″
Δ			4893″
	h.	m.	s.
Æ Polaris	1	12	59.65
Sid. time at mean noon at this station			
Sid. interval from mean time of culmination			
Retardation of mean on sidereal time			
Mean time of culmination of star			
Error of chron. at time of observation	1	05	36.10
Time by chron. of culmination	2	18	35.75
Clock-time of observation	18	57	34.75
Hour-angle, p, in sid. time	7	21	01.
Sidereal equivalents in arc	110°	15′	15″
p in arc			

Determination of latitude by circum meridian altitudes.

Station, Camp Lewis, Montana.—Date, July 25, 1875.—Object observed, α Ophiuchi.—Sextant, Spencer Browning, 6536.—Index error, —20″.—Chronometer, Bond & Son, 202.—Observer, Wood.—Computer, Wood.—Bar., 25in. 95.—Ther., 58°.

Times of observation by chronometer.	Meridian distance = p.	$\frac{2 \sin^2 \frac{1}{2} p}{\sin 1''} = k$	$\frac{\cos l \cos D}{\cos a}$	Reduced to meridian in arc = x.	Observed 2 circum-meridian altitudes.	Observed altitudes, corrected for index error.	True altitudes = a.	True meridian altitudes deduced = $a + x$ = A.	Latitude deduced = 90° + D − A.
h. m. s.	′ ″	″		′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
18 26 45.5	8 00.5	126.	Constant multiplier, 1.176.	2 27	111 07 30	55 33 35	55 33 01	55 35 28	47 03 39
27 16.	7 30.	110.		2 08	08 40	34 10	33 36	44	13
27 44.	7 02.	97.		1 53	08 00	33 50	33 16	09	58
28 10.	6 36.	85.5		1 39	08 50	34 15	33 41	20	47
28 36.5	6 09.5	74.3		1 26	09 40	34 40	34 06	32	35
29 14.5	5 31.5	60.		1 10	10 10	34 55	34 21	31	36
29 45.5	5 00.5	49.		57	11 00	35 20	34 46	43	24
30 26.	4 20.	37.		43	11 20	35 30	34 56	39	28
30 54.	3 52.	29.		34	11 20	35 30	34 56	30	37
31 49.5	2 56.5	17.		20	11 30	35 35	35 01	21	46
32 19.	2 27.	12.		14	11 30	35 35	35 01	15	52
32 47.	1 59.	8.		9	11 50	35 45	35 11	20	47
33 22.5	1 23.5	4.		5	12 20	36 00	35 26	31	36
34 12.5	23.5	0.6		1	12 00	35 50	35 16	17	50
34 53.	7.	0.		0	12 50	36 15	35 41	41	26
35 38.5	52.5	1.5		2	12 00	35 50	35 16	18	49
36 16.5	1 30.5	4.5		5	12 00	35 50	35 16	21	46
36 50.5	2 04.5	8.5		10	12 10	35 55	35 21	31	36
37 30.	2 44.	14.7		17	12 00	35 50	35 16	33	34
38 01.5	3 15.5	21.		24	11 30	35 35	35 01	25	42
38 35.	3 49.	28.6		33	11 00	35 20	34 46	19	48
39 05.	4 19.	36.6		42	10 50	35 15	34 41	23	44
40 18.	5 32.	60.		1 10	10 30	35 05	34 31	41	26
40 47.5	6 01.5	71.		1 23	10 00	34 50	34 16	39	28
41 39.	6 53.	93.		1 48	09 40	34 40	34 06	54	13
42 10.	7 24.	107.5		2 03	08 00	33 50	33 16	19	48
42 42.5	7 56.5	124.		2 24	08 00	33 50	33 16	40	27
18 43 17.	8 31.	141.8		2 45	111 07 30	55 33 35	55 33 01	55 35 46	47 03 21
Mean									47 03 37

		°	′	″	
App. Lat. = l	=	47	03	50.	cos 9.83326
Dec.	=	12	39	07.4	cos 9.99932
a	=	55	35	20.	cos 0.24785
					0.07043

	h.	m.	s.	
				Semi-diam.
Chron. correction	1	05	36	Refraction 34″
Æ of ✱	17	29	10	Parallax.
	18	34	46	

Observation for time.

Station, Camp Lewis, Montana.—Date, September 10, 1875.—Object observed, Arcturus.—Sextant, Spencer Browning, 6536.—Chronometer, Bond & Son, 202.—Index error, 1′ 20″.—Observer, Wood.—Computer, Wood.—Bar., 25in.75.—Ther., 50°.

Double altitudes observed. ° ′ ″	Corresponding times. h. m. s.
60 40 00	20 02 08
	02 37.
	03 06.5
	03 36.
	04 05.
	04 35.5
59 40 00	20 05 04.5
60 10 00	20 03 35.93

		° ′ ″
Refraction = R	=	1 26
Parallax = P	=	
Semi-diam. = Sd	=	
R, P, and Sd	=	
Observed 2 alt.	=	60 10 00
Index error	=	1 20
2 alt. corrected	=	60 08 40
Altitude	=	30 04 20
R, P, and Sd	=	— 1 26
True alt. = A	=	30 02 54
log cos L	=	9.8332634
log sin Δ	=	9.9734435
log cos L sin Δ	=	9.8067069

		° ′ ″
Latitude = L	=	47 03 50
N. polar dist. = Δ	=	70 10 00
True altitude = A	=	30 02 54
2 *m* = L + Δ + A	=	147 16 44
m	=	73 38 22
m—A	=	43 35 28
log cos *m*	=	9.4497575
log sin (*m*—A)	=	9.8385388
log cos *m* sin (*m*—A)	=	19.2882963
log cos L sin Δ	=	9.8067069
log sin² ½ *p*	=	19.4815894
log sin ½ *p*	=	9.7407947
		° ′ ″
½ *p*	=	33 24 16
p in arc	=	66 48 32
		h. m. s.
p in time	=	4 27 14.13
*Æ	=	14 09 58.65
Equation of time	=	
True time	=	18 37 12.78
Time by chron.	=	20 03 35.93
Chron.	=	1 26 23.15

Determination of the latitude by observed double altitudes of Polaris off the meridian.

Station, Camp Lewis, Montana.—Date, September 10, 1875.—Sextant, Spencer Browning, 6536.—Index error, — 1′ 20″.—Chronometer, Bond & Son, 202.—Observer, Wood.—Computer, Wood.—Bar., 25in.75. Ther., 50°.

Observed double altitudes. °	′	″	Corresponding times. h.	m.	s.
93	50	30	20	14	34.5
	51	20		15	31.
	52	00		16	35.
	53	50		18	25.
	54	10		19	53.5
	55	10		20	32.
	55	40		20	59.
	56	00		21	37.
	56	10		22	12.
	56	30		22	38.5
	56	40		23	05.
	57	10		23	45.5
93	57	30	20	24	17.5
93	54	49	20	20	19.96
	1	20			
93	53	29			
46	56	45			
		50			
46	55	55			

		°	′	″
log cos p	= 8.9318631			
log Δ	= 3.6884198			
log Δ cos p	= 2.6202829			
	= 417″.1			
1st term	=		6	57.1
Alt. = A	=	46	55	55.
2d term	=		1	01.3
Latitude	=	47	03	53

log sin p	9.99841
log Δ	3.68842
log Δ sin p	3.68683
log (Δ sin p)^2	7.37366
log a	4.38454
log tan A	0.02931
log 2d term	1.78751
2d term	61″.3

Refraction	50″
Chron. correction	1h 26m 23s.15
Dec	88° 38′ 40″
Δ	4880″

	h.	m.	s.
Æ Polaris	1	13	33.66
Sid. time at mean noon at this station			
Sid. interval from mean time of culmination			
Retardation of mean on sidereal time			
Mean time of culmination of star			
Error of chron. at time of observation	1	26	23.15
Time by chron. of culmination	2	39	56.81
Clock-time of observation	20	20	19.96
Hour angle, p, in sid. time	6	19	36.85
Sidereal equivalents in arc	94°	54′	13″
p in arc			

Determination of the time by observed equal altitudes of the sun's limb.

TO CORRECT THE CHRONOMETER AT NOON.

Station, Camp Baker, Montana.—Date, July 31, 1875.—Sextant, Spencer Browning, 6536.—Chronometer, Arnold & Dent, 1362.—Observer, Wood.—Computer, Wood.

Observed double altitudes.	Corresponding times. A. M. = t	P. M. = t'	$t - t'$ = elapsed time.	Equation of equal altitudes = x.	Chron. fast of mean time at appt. noon by each pair of equal altitudes.
° ′ ″	h. m. s.	h. m. s.	h. m.	s.	h. m. s.
73 20 00	9 39 53. 5	5 00 45. 5			
	40 07.	00 30. 5			
	40 23. 5	00 15.			
	40 38.	00 00. 5			
	40 52. 5	4 59 45. 5			
	41 07.	59 30. 5			
	41 24.	59 16. 5	7 18	+ 9. 60	1 14 21. 94
	41 37. 5	59 01.			
	41 53.	58 45. 5			
	42 08. 5	58 31.			
	42 23.	58 16.			
	42 38. 5	58 01.			
74 20 00	9 42 53.	4 57 46.			
	9 41 23.	4 59 15. 73			

$T = 7^h\ 18^m$

$\delta = 37''.03$

$L = 46^\circ\ 40'\ 40''$

1st term $= +\ 11^s.70$

2d term $= -\ 2^s.10$

$x = +\ 9^s.60$ = equation of equal altitudes.

log A (page 164) = — 9. 4742
log δ = — 1. 5687
log tan = 0. 0254
= + 1. 0683

log B = 9. 2355
log δ = — 1. 5687
log tan D = 9. 5182
= — 0. 3224

h.	m.	s.
16	59	15. 73
9	41	23.
26	40	38. 73
13	20	19. 36
+		9. 60
13	20	28. 96
12	06	07. 02
1	14	21. 94

Determination of latitude by circum-meridian altitudes.

Station, Camp Baker, Montana.—Date, July 31, 1875.—Object observed, $\underline{\odot}$ — Sextant, Spencer Browning, 6536.—Index error, — 50″.—Chronometer, Arnold & Dent, 1862.—Observer, Wood.—Computer, Wood.—Bar., 25in.20.—Ther., 85°.

Times of observation by chronometer.	Meridian distance = p.	$\frac{2 \sin^2 \frac{1}{2} p}{\sin 1''} = k$.	$\frac{\cos l \cos D}{\cos a}$.	Reduced to meridian in arc = x.	Observed 2 circum-meridian altitudes.	Observed altitudes, corrected for index error.	True altitudes = a.	True meridian altitudes deduced = $a + x$ = A.	Latitude deduced = 90° + D — A.
h. m. s	′ ″	″		′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1 10 37.5	9 51.5	190.8	Constant multiplier, 1.368.	4 21	123 33 10	61 46 10	61 30 01	61 34 22	46 40 43
11 11.5	9 17.5	169.5		3 52	122 30 50	61 15 00	30 27	34 19	40 46
11 43.	8 46.	151.0		3 25	123 34 50	61 47 00	30 51	34 16	40 49
12 12.	8 17.	134.7		3 04	122 32 00	61 15 35	31 02	34 06	40 59
12 35.5	7 53.5	122.2		2 50	123 35 50	61 47 30	31 21	34 11	40 54
13 01.5	7 27.5	109.3		2 29	122 32 50	61 16 00	31 27	33 56	40 69
13 42.5	6 46.5	90.0		2 03	123 37 20	61 48 15	32 06	34 09	40 56
14 19.5	6 09.5	74.5		1 42	122 35 00	61 17 05	32 32	34 14	40 51
14 47.5	5 41.5	63.6		1 27	123 38 40	61 48 55	32 46	34 13	40 52
15 22.5	5 06.5	51.2		1 10	122 35 40	61 17 25	32 52	34 02	40 63
16 03.	4 26.	38.6		53	123 40 20	61 49 45	33 36	34 29	40 36
16 31.	3 58.	31.0		42	122 36 30	61 17 50	33 17	33 59	40 66
17 06.5	3 22.5	22.4		31	123 41 00	61 50 05	33 56	34 27	40 38
17 47.	2 42.	14.3		20	122 37 10	61 18 10	33 37	33 57	40 68
18 15.	2 14.	9.8		13	123 41 20	61 50 15	34 06	34 19	40 46
18 45 5	1 43.5	5.8		8	122 37 50	61 18 30	33 57	34 05	40 60
19 21.5	1 07.5	2.4		3	123 42 10	61 50 40	34 31	34 34	40 31
19 55.	34.	0.6		1	122 38 10	61 18 40	34 07	34 08	40 57
20 32.	3.	0.0		0	123 42 00	61 50 35	34 26	34 26	40 39
20 58.5	29.5	0.5		1	122 38 00	61 18 35	34 02	34 03	40 62
21 33.5	1 04.5	2.3		3	123 42 00	61 50 35	34 26	34 29	40 36
22 16.	1 47.	6.3		8	122 38 00	61 18 35	34 02	34 10	40 55
22 44.5	2 15.5	10.0		14	123 41 20	61 50 15	34 06	34 20	40 45
23 24.5	2 54.5	16.6		23	122 37 20	61 18 15	33 42	34 05	40 60
23 55.	3 26.	23.0		32	123 41 10	61 50 10	34 01	34 33	40 32
24 32.	4 03.	32.2		44	122 36 40	61 17 55	33 22	34 06	40 59
25 00.	4 31.	40.1		55	123 40 40	61 49 55	33 46	34 41	40 24
25 30.5	5 01.5	49.5		1 08	122 36 00	61 17 35	33 02	34 10	40 55
25 56.	5 27.	58.3		1 19	123 39 00	61 49 05	32 56	34 15	40 50
26 21.5	5 52.5	67.8		1 33	122 34 50	61 17 00	32 27	34 00	40 65
26 52.	6 23.	80.0		1 49	123 37 30	61 48 20	32 11	34 00	40 65
27 24.5	6 55.5	94.1		2 09	122 34 30	61 16 50	32 17	34 26	40 39
27 57.5	7 28.5	109.7		2 30	123 37 30	61 48 20	32 11	34 41	40 24
28 29.5	8 00.5	126.0		2 52	122 32 20	61 15 45	31 12	34 04	40 61
29 11.5	8 42.5	149.0		3 24	123 35 10	61 47 10	31 01	34 25	40 40
29 42.5	9 13.5	167.0		3 48	122 30 40	61 14 55	30 22	34 10	40 55
30 12.	9 43.	185.4		4 14	123 33 20	61 46 15	30 06	34 20	40 45
1 30 41.5	10 12.5	204.5		4 40	122 29 20	61 14 15	61 29 42	61 34 22	46 40 43
Mean									46 40 49

	° ′ ″
90	
18 15 05	
108 15 05	

		° ′ ″		
App. lat.	= l =	46 40 40	cos	9.83639
Dec.	=	18 15 05	cos	9.97758
a	=	41 33	cos	0.32204
		1.3677		0.13601

	h. m. s.
Chron. correction	1 14 21.94
Equation of time	6 07.02
	1 20 28.96

	′ ″	′ ″
Semi-diam.	— 15 47.9	+ 15 47.9
Refraction	— 24.9	— 24.9
Parallax	+ 4.2	+ 4.2
	— 16 08.6	+ 15 27.2

Determination of the latitude by observed double altitudes of Polaris off the meridian.

Station, Camp Baker, Montana.—Date, July 31, 1875.—Ref. Circle, Gambay & Son, 212.—Chronometer, Bond & Son, 202.—Observer, Wood.—Computer, Wood.—Bar., 25^in.24.—Ther., 60°.

Observed double altitudes. ° ′ ″	Corresponding times. h. m. s.
	18 35 49.5
	36 48
	37 22
	37 57
	38 22.5
	38 53
	39 23
	40 32
720 00 00	41 19.5
201 22 20	18 41 54
921 22 20	18 38 50.05
92 08 14	
46 04 07	
46	
46 03 21	

$\log \cos p$	=	9.6527431
$\log \Delta$	=	3.6894864
$\log \Delta \cos p$	=	3.3422295
	=	2199″
		° ′ ″
1st term	=	36 39
Alt. = A	=	46 03 21
2d term	=	48
Latitude	=	46 40 48

$\log \sin p$	9.95098
$\log \Delta$	3.68949
$\log \Delta \sin p$	3.64047
$\log (\Delta \sin p)^2$	7.28094
$\log a$	4.38454
$\log \tan A$	0.01601
log 2d term	1.68149
2d term	48″

Refraction	46″
Chron. correction	— 1h 12m 25s.05
Dec	1° 21′ 32″
Δ	4892″

	h. m. s.
Æ Polaris	1 13 05
Sid. time at mean noon at this station	
Sid. interval from mean time of culmination	
Retardation of mean on sidereal time	
Mean time of culmination of star	
Error of chron. at time of observation	1 12 35
Time by chron. of culmination	2 25 40
Clock-time of observation	18 38 50
Hour-angle, p in sid. time	7 46 50
Sidereal equivalents in arc	116° 42′ 30″
p in arc	

Determination of latitude by circum-meridian altitudes.

Station, Camp Baker, Montana.—Date, August 1, 1875.—Object observed, ⨀.—Sextant, Spencer Browning, 6536.—Index error, − 33″.—Chronometer, Arnold & Dent, 1362.—Observer, Wood.—Computer, Wood.—Bar., 25in.20.—Ther., 85°.

Times of observation by chronometer.	Meridian distance = p.	$\frac{2 \sin^2 \frac{1}{2} p}{\sin 1''} = k$.	$\frac{\cos l \cos D}{\cos a}$.	Reduced to meridian in arc = x.	Observed 2 circum-meridian altitudes.	Observed altitudes, corrected for index error.	True altitudes = a.	True meridian altitudes deduced = $a + x$ = A.	Latitude deduced = 90° + D − A.
h. m. s.	′ ″	″		′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1 14 17.	6 09	74. 3	Constant multiplier, 1.36.	1 41	122 05 00	61 02 13	61 17 40	61 10 21	46 40 44
14 53. 5	5 33	60. 5		1 22	123 08 30	61 33 59	61 17 50	61 19 12	46 40 53
15 40. 5	4 46	44. 6		1 01	122 06 40	61 03 03	61 18 30	61 19 31	46 40 34
16 26.	4 00	31. 4		43	123 09 40	61 34 34	61 18 25	61 19 08	46 40 57
16 48.	3 38	26. 0		35	122 06 40	61 03 03	61 18 30	61 19 05	46 40 60
17 21. 5	3 05	18. 7		25	123 10 30	61 34 59	61 18 50	61 19 15	41 40 50
17 49.	2 37	13. 4		18	122 07 20	61 03 23	61 18 50	61 19 08	46 40 57
18 33. 5	1 53	7. 0		9	123 10 40	61 35 04	61 18 55	61 19 04	46 40 61
19 11. 5	1 15	3. 0		4	122 07 40	61 03 33	61 19 00	61 19 04	46 40 61
19 40.	46	1. 0		1	123 11 10	61 35 19	61 19 10	61 19 11	46 40 54
20 13. 5	13	0. 0		0	122 08 00	61 03 43	61 19 10	61 19 10	46 40 55
20 44.	18	0. 0		0	123 11 10	61 35 19	61 19 10	61 19 10	46 40 55
21 09. 5	43	1. 0		1	122 07 50	61 03 36	61 19 03	61 19 04	46 40 61
21 40. 5	1 14	3. 0		4	123 11 00	61 35 14	61 19 05	61 19 09	46 40 56
22 04.	1 38	5. 2		7	122 07 50	61 03 36	61 19 03	61 19 10	46 40 55
22 36.	2 10	9. 2		12	123 10 40	61 35 04	61 18 55	61 19 07	46 40 58
23 09.	2 43	14. 5		20	122 07 10	61 03 18	61 18 45	61 19 05	46 40 60
23 41.	3 15	20. 7		28	123 10 10	61 34 48	61 18 39	61 19 07	46 40 53
24 25.	3 59	31. 1		42	122 06 40	61 03 03	61 18 30	61 19 12	46 40 53
25 02.	4 36	41. 5		56	123 09 20	61 34 24	61 18 15	61 19 11	46 40 54
25 38.	5 12	53. 1		1 12	122 05 30	61 02 28	61 17 55	61 19 07	46 40 58
26 05.	5 39	62. 7		1 25	123 08 30	61 33 59	61 17 50	61 19 15	46 40 50
26 29. 5	6 03	71. 9		1 38	122 04 40	61 02 03	61 17 30	61 19 08	46 40 57
1 26 48. 5	6 22	79. 6		1 48	123 07 40	61 33 34	61 17 25	61 19 13	46 40 52
				24) 15 12	122 38 20				
					33				
				38	2) 122 37 47				
					61 18 53. 5				
					21				
					61 18 32. 5				
					38				
					61 19 10. 5				
					108 00 04. 7				
					46 40 54. 2				
Mean									46 40 54. 4

	90 00 00. 0
	18 00 04. 7
	108 00 04. 7
	61 10 21.
	46 40 44

		° ′ ″	
App. lat.	= l =	46 40 45	cos 9. 83638
Dec.	=	18 00 04. 7	cos 9. 97820
a	=	61 18 30	cos 0. 31867
			0. 13325

	h. m. s.
Chron. correction	1 14 22. 38
Equation of time	6 03. 83
	1 20 26. 21

	′ ″	′ ″
Semi-diam.	−15 48.	+15.48.
Refraction	− 25. 2	− 25. 2
Parallax	+ 4. 2	+ 4. 2
	−16 09.	+15 27.

Determination of latitude by circum-meridian altitudes.

Station, Camp Baker, Montana.—Date, August 3, 1875.—Object observed, $\overline{\odot}$.—Sextant, Spencer Browning, 6536.—Index error, --25″.—Chronometer, Arnold & Dent, 1362.—Observer, Wood.—Computer, Wood.—Bar 25^{in}.20.—Ther., 86.

Times of observation by chronometer.	Meridian distance = p.	$\frac{2 \sin^2 \frac{1}{2} p}{\sin 1''} = k$	$\frac{\cos l \cos D}{\cos a}$	Reduced to meridian in arc = x.	Observed 2 circum-meridian altitudes	Observed altitudes, corrected for index-error.	True altitudes = a.	True meridian altitudes deduced = $a + x$ = A.	Latitude deduced = 90° + D − A.
h. m. s.	′ ″	″		′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1 12 59.5	7 20	105.6	Constant multiplier, 1.385.	2 26	122 05 00	61 02 17	61 46 07	61 48 33	46 40 38
13 28.5	6 51	92.1		2 07	121 02 20	60 30 58	46 25	48 32	39
13 53.5	6 26	81.3		1 53	122 06 00	61 02 47	46 37	48 30	41
14 24.5	5 55	68.7		1 35	121 03 10	60 31 23	46 50	48 25	46
14 51.5	5 28	58.7		1 21	122 07 00	61 03 17	47 07	48 28	43
15 23	4 56	47.8		1 06	121 04 10	60 31 53	47 20	48 26	45
16 01	4 18	36.3		50	122 08 10	61 03 52	47 42	48 32	39
16 32	3 47	28.1		39	121 05 00	60 32 18	47 45	48 24	47
17 00	3 19	21.6		29	122 08 40	61 04 07	47 57	48 26	45
17 27.5	2 52	16.1		22	121 05 30	60 32 33	48 00	48 22	49
18 04.5	2 15	10.0		14	122 09 40	61 04 37	48 27	48 41	30
18 28	1 51	6.7		9	121 05 30	60 32 33	48 00	48 09	62
19 00.5	1 19	3.4		4	122 09 50	61 04 42	48 32	48 36	35
19 30.5	49	1.3		1	121 06 20	60 32 58	48 25	48 26	45
20 00.5	19	0.0		0	122 09 40	61 04 37	48 27	48 27	44
20 30.5	11	0.0		0	121 06 10	60 32 53	48 20	48 20	51
21 52.5	1 33	4.7		6	122 09 20	61 04 27	48 17	48 23	48
22 37	2 18	10.4		14	121 05 40	60 32 38	48 05	48 19	52
23 09	2 50	15.8		22	122 09 00	61 04 17	48 07	48 29	42
23 34	3 15	20.7		29	121 05 20	60 32 28	47 55	48 24	47
24 03	3 44	27.4		38	122 08 20	61 03 57	47 47	48 25	46
24 36	4 17	36.0		50	121 04 50	60 32 13	47 40	48 30	41
25 08	4 49	45.5		1 03	122 07 40	61 03 37	47 27	48 30	41
25 50	5 31	59.8		1 22	121 03 30	60 31 33	47 00	48 22	49
26 42.5	6 23	80.0		1 51	122 06 10	61 02 52	46 42	48 33	38
27 14.5	6 55	94.0		2 10	121 02 00	60 30 48	61 46 15	61 48 25	46 40 46
Mean									46 40 44

	°	′	″
	90	00	00
	17	29	11
	107	29	11
	61	48	33
	46	40	38

	°	′	″	
App. lat. = l	= 46	40	40	cos 9.83648
Dec.	= 17	29	11	cos 9.97943
a	= 61	48		cos 0.32555
		1.385		1.14148

	h.	m.	s.
Chron. correction	1	14	23.7
Equation of time		5	55.5
	1	20	9.2

	′	″	′	″
Semi-diam.	− 15	48.4	+ 15	48.3
Refraction	—	25.6	—	25.6
Parallax	+	4.3	+	4.3
	− 16	09.6	+ 15	27.0

Determination of latitude by circum-meridian altitudes.

Station, Camp Baker, Montana.—Date, August 4, 1875.—Object observed, α Ophiuchi.—Sextant, Spencer Browning, 6536.—Chronometer, Bond & Son, 202.—Observer, Wood.—Computer, Wood.—Bar., 25in.22.—Ther., 57°.

Times of obs. by chron.			Mer. dist. = p		$\frac{2 \sin^2 \frac{1}{2} p}{\sin 1'' = k}$	$\frac{\cos l \cos D}{\cos a}$	Red. to mer. in arc = x.	Obs'd 2 circum-meridian altitudes.		
h.	m.	s.	′	″	″		″	°	′	″
18	31	34.	10	12.	204. 2			111	50	40
	32	20.	9	26.	174. 7				51	30
	33	07. 5	8	38. 5	146. 6				53	00
	33	51.	7	55.	123. 1				53	50
	34	32. 5	7	13. 5	102. 5				54	50
	35	09.	6	37.	86. 0				55	20
	36	11.	5	35.	61. 2				56	00
	37	14. 5	4	31. 5	40. 2				56	50
	38	06.	3	40.	26. 4				57	30
	38	43. 5	3	02. 5	18. 2				58	00
	39	22.	2	24. 0	11. 3				58	10
	40	13.	1	33.	4. 7				58	20
	41	00. 5		45. 5	1. 1				58	50
	41	53. 5		07. 5	0. 0	Constant multiplier, 1.196.	85. 1		58	20
	42	54.	1	08.	2. 5				58	30
	43	51. 5	2	05. 5	8. 6				58	20
	44	38. 5	2	52. 5	16. 2				58	10
	45	25.	3	39.	26. 2				57	50
	46	10.	4	24.	38. 0				56	40
	46	55. 5	5	09. 5	52. 3				56	20
	47	32. 5	5	46. 5	65. 5				56	00
	48	16.	6	30.	83. 0				55	10
	48	53.	7	07.	99. 7				54	20
	49	31.	7	45.	117. 9				54	00
	50	34. 5	8	48. 5	152. 3				52	30
18	51	32.	9	46.	187. 3			111	51	50
					71. 14			111	55	48
										60
								111	54	48
								55	57	24
										32
								55	56	52
									1	25. 1
								55	58	17. 1
								102	39	08. 6
								46	40	51. 5

		°	′	″		
App. lat. = l	=	46	40	40.	cos	9. 83648
Dec.	=	12	39	08. 6	cos	9. 98932
a	=	55	57		cos	0. 25188
			1. 196			0. 07768

	h.	m.	s.	
Chron. correction	1	12	35. 65	Semi-diam.
⁎Æ	17	29	10. 38	Refraction — 32″
				Parallax.
Equation of time	18	41	46. 03	

Determination of the latitude by observed double altitudes of Polaris off the meridian.

Station, Camp Baker, Montana.—Date, August 4, 1875.—Ref. circle, Gambay & Son, 212.—Chronometer, Bond & Son, 202.—Observer, Wood.—Computer, Wood.—Bar., 25^{in} 22.—Ther., 57°.

Observed double altitudes.	Corresponding times.				
° ′ ″	h. m. s.				
	19 37 17.	log cos p	= 9.2947207	log sin p	9.991395
	37 59.5	log Δ	= 3.6893977	log Δ	3.689398
	38 48.				
	39 26.	log Δ cos p	= 2.9841184	log Δ sin p	3.680793
	39 58.5		= 964″.1		
	40 32.		° ′ ″	log (Δ sin p)^2	7.36159
	41 17.5			log a	4.38454
	41 53.	1st term	= 16 04.1	log tan A	.02125
208 17 00	42 25.	Alt. = A	= 46 24 05.		
720 00 00	19 42 56.	2d term	= 58.5	log 2d term	1.76738
				2d term	58″.5
10)928 17 00	19 40 15.25	Latitude	= 46 41 07.6		
92 49 42					
46 24 51					
46					
46 24 05					

Refraction			46″
Chron. correction	1h	12m	35s.65
Dec	88°	39′	29″
Δ			4891″
	h.	m.	s.
Æ Polaris	1	13	08.00
Sid. time at mean noon at this station			
Sid. interval from mean time of culmination			
Retardation of mean on sidereal time			
Mean time of culmination of star			
Error of chron. at time of observation	1	12	35.65
Time by chron. of culmination	2	25	43.65
Clock-time of observation	19	40	15.25
Hour-angle, p, in sid. time	6	45	28.
Sidereal equivalents in arc	101°	22′	06′
p in arc			

Determination of latitude by circum-meridian altitudes.

Station, Camp Baker, Montana.—Date, August 4, 1875.—Object observed, η Serpentis.—Sextant, Spencer Browning, 6536.—Index error, —30″.—Chronometer, Bond & Son, 202.—Observer, Wood.—Computer, Wood.—Bar., 25in.22.—Ther., 57°.

Times of obs. by chron.	Mer. dist. $=p$.	$\frac{2 \sin^2 \frac{1}{2} p}{\sin 1'' = k.}$	$\frac{\cos l \cos D}{\cos a.}$	Red. to mer. in arc $=x$.	Obs'd 2 circum meridian altitudes.
h. m. s.	′ ″	″		″	° ′ ″
19 23 18.5	4 10.5	34.3			80 49 00
24 07.	3 22.	22.3			49 00
24 49.	2 40.	14.0			49 00
25 37.5	1 41.5	5.7			49 10
26 42.5	46.5	1.2			49 10
27 19.5	09.5	.0			49 30
28 01.	32.	.6	Constant multiplier, .879.	13	49 30
28 42.	1 13.	2.9			49 20
29 19.	1 50.	6.6			49 10
30 04.5	2 35.5	13.2			49 00
30 46.	3 17.	21.2			49 00
31 24.	3 55.	30.1			48 10
19 32 11.	4 42.	43.4			80 47 40
		15.0			80 48 58
					30
					80 48 28
					40 24 14
					57
					40 23 17
					13
					40 23 30
					87 04 12
					46 40 42

	°	′	″	
App. lat. $=l=$	46	40	40.	cos 9.83648
Dec. $=$S.	2	55	48.3	cos 9.99943
a $=$	40	23	0.	cos 0.11824
			.879	9.94415

	h.	m.	s.	
				Semi diam.
Chron. correction	1	12	35.65	Refraction 57″
⚹ Æ	18	14	53.22	Parallax
	19	27	28.87	

Observation for time.

Station, Camp Baker, Montana.—Date, August 5, 1875.—Object observed, Altair.—Ref. circle, Gambay & Son, 212.—Chronometer, Bond & Son, 202.—Observer, Wood.—Computer, Wood.—Bar., 25in.30.—Ther. 53°.

Double altitude observed. °	′	″	Corresponding times. h.	m.	s.
			18	24	55. 5
				25	47. 5
				26	16.
				27	06. 5
				27	37.
				28	07. 5
				28	40.
				29	15. 5
86	53	30		29	46.
720	00	00	18	30	24. 5
806	53	30	18	27	47. 6
80	41	21			
40	20	40. 5			
		56. 8			
40	19	44			

		″
Refraction = R	=	56. 8
Parallax = P	=	
Semi-diam. = Sd	=	
R, P, and Sd	=	
Observed 2 alt.	=	
Index error	=	
2 alt. corrected	=	
Altitude	=	
R, P, and Sd	=	
True alt. = A	=	
log cos L	=	9. 8363878
log sin Δ	=	9. 9951569
log cos L sin Δ	=	9. 8315447

		°	′	″
Latitude = L	=	46	40	40
N. polar dist. = Δ	=	81	27	33
True altitude = A	=	40	19	44
2 *m* = L + Δ + A	=	168	27	57
m	=	84	13	58. 5
m—A	=	43	54	14. 5
log cos *m*	=	9. 0021000		
log sin (*m*—A)	=	9. 8410167		
log cos *m* sin (*m*—A)	=	18. 8431167		
log cos L sin Δ	=	9. 8315447		
log sin² ½ *p*	=	19. 0115720		
log sin ½ *p*	=	9. 5057860		
		°	′	″
½ *p*	=	18	41	29
p in arc	=	37	22	58
		h.	m.	s.
p in time	=	2	29	31. 87
✱ Æ	=	19	44	43. 9
True time	=	17	15	12
Time by chron.	=	18	27	47. 6
Chron. fast	=	1	12	35. 6

Observation for time.

Station, Camp Baker, Montana.—Date, August 5, 1875.—Object observed, Arcturus.—Ref. circle, Gambay & Son, 212.—Chronometer, Bond & Son, 202.—Observer, Wood.—Computer, Wood.—Bar., 25in.30.—Ther., 53°.

Double altitudes observed. °	′	″	Corresponding times. h.	m.	s.
			18	51	44.
				52	56. 5
				53	30.
				54	07.
				54	34.
				54	59. 5
				55	29.
				55	55. 5
68	49	30		56	28. 5
720	00	00	18	56	55. 5
10)788	49	30	18	54	39. 95
78	52	57			
39	26	28. 0			
		58			
39	25	30			

		″
Refraction = R	=	58
Parallax = P	=	
Semi-diam. = Sd	=	
R, P, and Sd	=	
Observed 2 alt.	=	
Index error	=	
2 alt. corrected	=	
Altitude	=	
R, P, and Sd	=	
True alt. = A	=	
log cos L	=	9. 8363878
log sin Δ	=	9. 9734435
log cos L sin Δ	=	9. 8098313

		°	′	″
Latitude = L	=	46	40	40
N. polar dist. = Δ	=	70	10	00
True altitude = A	=	39	25	30
2 *m* = L + Δ + A	=	156	16	10
m	=	78	08	05
m—A	=	38	42	35
log cos *m*	=	9. 3130467		
log sin (*m*—A)	=	9. 7961406		
log cos *m* sin (*m*—A)	=	19. 1091873		
log cos L sin Δ	=	9. 8098313		
log sin² ½ *p*	=	19. 2993560		
log sin ½ *p*	=	9. 6496780		
		°	′	″
½ *p*	=	26	30	36
p in arc	=	53	01	12
		h.	m.	s.
p in time	=	3	32	04. 8
✱ Æ	=	14	09	59. 1
True time	=	17	42	03. 9
Time by chron.	=	18	54	39. 95
Chron. fast	=	1	12	36. 0

Determination of latitude by circum-meridian altitudes.

Station, Camp Baker, Montana.—Date, August 5, 1875.—Object observed, α Ophiuchi.—Ref. circle, Gambay & Son, 212.—Chronometer, Bond & Son, 202.—Observer, Wood.—Computer, Wood.—Bar., 25in.30.—Ther., 53°.

Times of obs. by chron.	Mer. dist. = p.	$\frac{2 \sin^2 \frac{1}{2} p}{\sin 1'' = k}$.	$\frac{\cos l \cos D}{\cos a}$	Red. to mer. in arc = x.	Observed 2 circum-meridian altitudes.
h. m. s.	′ ″	″		″	° ′ ″
18 35 33.5	6 13	75.9	Cons't multiplier, 1.196.	40.8	
37 54.5	3 52	29.4			
38 51.	2 55	16.7			
39 51.	1 55	7.2			
40 52.5	54	1.6			
41 59.5	13				
43 10.5	1 24	3.9			
44 18.	2 32	12.6			
45 17.	3 31	24.3			
46 41.	4 56	47.8			
47 58.5	6 12	75.5			
18 49 24.	7 38	114.4			623 26 40
					720 00 00
		34.1			12)1343 26 40
					111 57 13.3
					55 58 36.6
					33
					55 58 03.6
					40.8
					55 58 44.4
					102 39 08.7
					46 40 24

	° ′ ″		
App. lat. = l	= 46 40 40		cos 9.83648
Dec.	= 12 39 08.7		cos 9.98932
a	= 55 58		cos 0.25206
		1.196	0.07786

	h. m. s.	
Chron. correction	1 12 35.8	Semi-diam.
Equation of time	17 29 10.4	Refraction 33″
		Parallax
	18 41 46.2	

Determination of latitude by circum-meridian altitudes.

Station, Camp Baker, Montana.—Date, August 5, 1875.—Object observed, η Serpentis.—Ref. circle, Gambay & Son, 212.—Chronometer, Bond & Son, 202.—Observer, Wood.—Computer, Wood.—Bar., 27in. 30.—Ther., 53°.

Times of obs. by chron.	Mer. dist. $= p$.	$\frac{2 \sin^2 \frac{1}{2} p.}{\sin 1'' = k}$	$\frac{\cos l \cos D}{\cos a}$	Obs'd 2 circum-meridian altitudes.
h. m. s.	′ ″	″		° ′ ″
19 23 15.	4 14.	35. 2	Constant multiplier, .879	
24 53. 5	2 35. 5	13. 2		
25 55.	1 34.	4. 8		
26 55. 5	33. 5	0. 6		
27 56. 5	27. 5	0. 4		
28 54.	1 25.	3. 9		
30 24. 5	2 55. 5	16. 8		
19 31 34.	4 05.	32. 7		8) 646 29 00
		13. 45		80 48 37. 5
				40 24 18. 7
				56. 4
				40 23 22. 3
				11. 4
				40 23 34. 1

	° ′ ″	
App. lat. $= l =$	46 40 40	cos 9. 83648
Dec. $=$	2 55 48. 3	cos 9. 99943
$a =$	40 23 20	cos 0. 11824
	. 879	9. 94415

	h. m. s.		
Chron. correction	1 12 35. 8	Semi-diam.	
✱ Æ	18 14 53. 2	Refraction	56″. 4
		Parallax.	
	19 27 29. 0		

Determination of the latitude by observed double altitudes of Polaris off the meridian.

Station, Camp Baker, Montana.—Date, August 5, 1875.—Ref. circle, Gambay & Son, 212.—Chronometer Bond & Son, 202.—Observer, Wood.—Computer, Wood.—Bar., 25in. 30.—Ther., 53°.

Observed double altitudes.	Corresponding times.				
° ′ ″	h. m. s.				
	19 34 18.5	log cos p	= 9.3227046	log sin p	9.99018
	34 48.	log Δ	= 3.6893977	log Δ	3.68940
	35 31.				
	36 30.	log Δ cos p	= 3.0121023	log Δ sin p	3.67958
	37 06.5		= 1028″.3		
	37 37.5			log (Δ sin p)²	7.35916
	38 08.5		° ′ ″	log a	4.38454
	38 44.	1st term	= 17 08.3	log tan A	.02091
207 50 00	39 17.5	Alt. = A	= 46 22 43.2		
720 00 00	19 39 57.5	2d term	58.2	log 2d term	1.76461
				2d term	58″.2
10) 927 50 00	19 37 11.9	Latitude	= 46 40 49.7		
92 47 00					
46 23 30					
46.8					
46 22 43.2					

Refraction	46″.8
Chron. correction	1h 12m 35s.8
Dec	88° 38′ 29″
Δ	4891″
	h. m. s.
Æ Polaris	1 13 08.76
Sid. time at mean noon at this station	
Sid. interval from mean time of culmination	
Retardation of mean on sidereal time	
Mean time of culmination of star	
Error of chron. at time of observation	1 12 35.8
Time by chron. of culmination	2 25 44.56
Clock-time of observation	19 37 11.9
Hour-angle, p, in mean time	6 48 32.66
Sidereal equivalents in arc	102° 08′ 10″
in arc	

Determination of the latitude by observed double altitudes of Polaris off the meridian.

Station, Camp Baker, Montana.—Date, August 5, 1875.—Sextant, Spencer Browning, 6536.—Index error, —60″.—Chronometer, Bond & Son, 202.—Observer, Wood.—Computer, Wood.—Bar., 25in. 30.—Ther. 53°.

Observed double altitudes.			Corresponding times.		
°	′	″	h.	m.	s.
92	30	30	19	11	51.5
	31	10		12	44.
	31	20		13	24.5
	31	50		14	01.5
	32	10		14	40.
	32	40		15	23.
	33	20		16	10.5
	34	00		16	49.5
	34	15		17	21.5
92	34	35	19	18	06.5
92	32	35	19	15	03.25
	1	00			
92	31	35			
46	15	47.5			
		46.8			
46	15	00.7			

log cos p	= 9.4822605			
log Δ	= 3.6893977			
log Δ cos p	= 3.1716582			
	= 1484″.8			
	°	′	″	
1st term	=	24	44.8	
Alt. = A	= 46	15	00.7	
2d term	=		55.0	
Latitude	= 46	40	40.5	

log sin p	9.97901
log Δ	3.68940
log Δ sin p	3.66841
log (Δ sin p)	7.33682
log a	4.38454
log tan A	0.01896
log 2d term	1.74032
2d term	55″.0

Refraction	46″.8
Chron. correction	1h 12m 35s.8
Dec	88° 38′ 29″
Δ	4891″

	h.	m.	s.
Æ Polaris	1	13	08.76
Sid. time at mean noon at this station			
Sid. interval from mean time of culmination			
Retardation of mean on sidereal time			
Mean time of culmination of star			
Error of chron. at time of observation	1	12	35.8
Time by chron. of culmination	2	25	44.56
Clock-time of observation	19	15	03.25
Hour-angle, p, in sid. time	7	10	41.3
Sidereal equivalents in arc	107°	40′	20″
p in arc			

Determination of the latitude by observed double altitudes of Polaris off the meridian.

Station, Camp Baker, Montana.—Date, August 5, 1875.—Ref. circle, Gambay & Son, 212.—Chronometer Bond & Son, 202.—Observer, Wood.—Computer, Wood.—Bar., 25in.30.—Ther., 53°.

Observed double altitudes.			Corresponding times.						
°	′	″	h.	m.	s.	log cos p	= 9.5388061	log sin p	9.97235
			19	01	49.5	log Δ	= 3.6893977	log Δ	3.68940
				02	41.5				
				03	07.5	log Δ cos p	= 3.2282038	log Δ sin p	3.66175
				03	53.5		= 1691″.2		
				04	24.5			log (Δ sin p)^2	7.32350
				05	07.		° ′ ″	log a	4.38454
				05	54.	1st term	= 28 11.2	log tan A	0.01817
				06	32.	Alt. = A	= 46 11 53.7		
204	13	30		07	00.	2d term	= 53.2	log 2d term	1.72621
720	00	00	19	07	45.			2d term	53″.2
						Latitude	= 46 40 58.1		
10)924	13	30	19	04	49.45				
92	25	21							
46	12	40.5							
		46.8							
46	11	53.7							

Refraction	46″.8
Chron. correction	1h 12m 35s.8
Dec	88° 38′ 29″
Δ	4891″
	h. m. s.
Æ Polaris	1 13 08.76
Sid. time at mean noon at this station	
Sid. interval from mean time of culmination	
Retardation of mean on sidereal time	
Mean time of culmination of star	
Error of chron. at time of observation	1 12 35.8
Time by chron. of culmination	2 25 44.56
Clock-time of observation	19 04 49.45
Hour-angle, p, in mean time	7 20 55.1
Sidereal equivalents in arc	110° 13′ 47″
p in arc	

Summary table of daily instrumental observations with deduced altitudes, latitude, and longitude of each camp, and of the Montana posts, distances traveled, &c.

Station.	Date.	Start.	Arrive.	Barometer.	Elevation.	Latitude.	Longitude.	Day's march.	Total distance.
	1875.	*h.*	*h.*	*In.*	*Feet.*	° ′ ″	° ′ ″	*Miles.*	*Miles.*
Carroll	July 13	9.00 a. m.	......	27.50	2,247	47 34 48	108 24 00	......	......
Little Crooked Creek	July 13	......	1.30 p. m.	26.80	2,923	47 30 01	108 34 30	13	13
Crooked Creek	July 16	8.00 a. m.	10.00 a. m.	26.95	2,776	47 28 00	108 41 30	6	19
Box Elder Creek	July 18	7.00 a. m.	2.30 p. m.	26.28	3,437	47 20 43	109 02 00	19.5	38.5
Camp Lewis	July 25	6.00 a. m.	5.00 p. m.	25.83	3,890	47 03 47	109 26 30	36	74.5
Ross's Fork	July 26	7.30 a. m.	4.30 p. m.	25.54	4,186	46 47 03	109 44 00	27	101.5
Haymaker's Creek	July 27	7.00 a. m.	4.20 p. m.	25.07	4,673	46 30 00	110 06 40	29	130.5
North Fork Musselshell	July 28	7.30 a. m.	2.00 p. m.	24.70	5,063	46 33 13	110 28 30	19.25	149.75
Brewer's Springs	July 29	7.45 a. m.	4.00 p. m.	24.80	4,957	46 32 50	110 55 40	27	176.75
Camp Baker	July 30	8.30 a. m.	1.15 p. m.	25.20	4,538	46 40 44	111 11 00	16.75	193.5
Moss Agate Springs	Aug. 7	8.00 a. m.	5.00 p. m.	24.66	5,106	46 23 40	110 53 30	27	220.5
Twenty-five Yard Creek	Aug. 8	6.30 a. m.	5.30 p. m.	24.58	5,191	46 00 05	110 48 40	32	252.5
Fort Ellis	Aug. 9	6.15 a. m.	5.00 p. m.	25.00	4,747	45 40 15	110 59 04	28.75	281.25
Drane's Dam	Aug. 10	8.00 p. m.	8.45 p. m.	......	......	......	......	1.5	282.75
Boteler's Ranch	Aug. 11	6.30 a. m.	7.30 p. m.	24.88	4,873	......	......	33.25	316
Rocky Cañon	Aug. 12	6.30 a. m.	12.30 p. m.	24.80	4,958	......	......	15.5	331.5
Mammoth Springs	Aug. 13	7.45 a. m.	6.40 p. m.	23.73	6,114	......	......	18	349.5
Meadow Brook	Aug. 15	8.20 a. m.	3.00 p. m.	23.80	6,037	......	......	15	364.5
Cascade Creek	Aug. 16	8.40 a. m.	5.00 p. m.	22.28	7,767	44 43 40	......	19.5	384
Mud Volcano	Aug. 18	8.20 a. m.	11.45 a. m.	22.40	7,626	44 37 17	......	11	395
Yellowstone Lake and return	Aug. 19	9.30 a. m.	2.30 p. m.	......	......	......	......	16	411
Lower Geyser Basin	Aug. 20	8.30 a. m.	5.00 p. m.	22.73	7,238	......	......	26	437
Upper Geyser Basin	Aug. 21	1.10 p. m.	4.20 p. m.	22.64	7,347	44 27 4	......	9	446
Jay Creek	Aug. 24	8.40 a. m.	7.30 p. m.	22.40	7,626	......	......	40	486
Meadow Brook	Aug. 25	8.00 a. m.	3.50 p. m.	......	......	......	......	23	509
Mammoth Springs	Aug. 26	7.50 a. m.	12.30 p. m.	......	......	......	......	15	524
Rocky Cañon	Aug. 27	12.30 p. m.	5.30 p. m.	......	......	......	......	18	542
Boteler's Ranch	Aug. 28	8.30 a. m.	12.30 p. m.	......	......	......	......	15	557
Sprague's Ranch	Aug. 29	8.50 a. m.	1.50 p. m.	......	......	......	......	16.5	573.5
Fort Ellis	Aug. 30	9.15 a. m.	1.50 p. m.	......	......	......	......	18.5	592
Bridger Creek	Sept. 2	3.00 p. m.	7.50 p. m.	......	......	......	......	6	598
Bridger Creek	Sept. 3	10.30 a. m.	4.00 p. m.	24.28	5,513	45 45 27	110 53 45	4	602
Bridger Pass	Sept. 4	8.20 a. m.	6.00 p. m.	23.70	6,147	45 53 40	110 53 30	10.25	612.25
Cottonwood Creek	Sept. 5	1.10 p. m.	7.00 p. m.	24.37	5,416	46 05 30	110 45 15	16	628.25
Deep Creek	Sept. 6	6.45 a. m.	5.30 p. m.	24.25	5,545	46 20 12	110 45 30	16.5	644.75
South Fork of Musselshell	Sept. 7	7.30 a. m.	4.00 p. m.	24.61	5,160	46 26 08	110 24 50	21.75	666.25
Hopley's Hole	Sept. 8	7.00 a. m.	6.15 p. m.	24.86	4,894	......	......	27.25	693.5
Buffalo Creek	Sept. 9	6.30 a. m.	1.30 p. m.	25.37	4,360	......	......	24	717.5
Camp Lewis	Sept. 10	6.45 a. m.	1.45 p. m.	25.83	3,890	......	......	21.5	739
Armell's Creek	Sept. 11	6.30 a. m.	3.30 p. m.	25.90	3,820	47 19 12	109 12 00	26	765
Dog Creek	Sept. 12	7.30 a. m.	3.45 p. m.	26.05	3,668	47 25 10	109 20 30	16.25	781.25
Judith River	Sept. 13	7.00 a. m.	7.30 p. m.	27.40	2,343	47 41 30	109 39 30	28	809.25
Near Dog Creek	Sept. 16	6.30 a. m.	3.30 p. m.	26.50	3,220	47 31 17	109 27 30	17.5	826.75
Armell's Creek	Sept. 17	6.30 a. m.	4.30 p. m.	......	......	......	......	23	849.75
Crooked Creek	Sept. 18	7.00 a. m.	4.45 p. m.	......	......	......	......	26	875.75
Carroll	Sept. 19	7.30 a. m.	2.15 p. m.	......	......	......	......	22.5	898.25
Fort Shaw	......	......	......	......	......	47 30 33	111 48 19.5	......	......
Fort Benton	......	......	......	......	......	47 49 38	110 39 48	......	......

Distances on the Missouri River from Bismarck to Benton, from a survey by Lieut. F. V. Greene, United States Engineers, under direction of Capt. W. J. Twining, Corps of Engineers.

From Bismarck.	To—	From Fort Benton.	From Bismarck.	To—	From Fort Benton.
Miles.		*Miles.*	*Miles.*		*Miles.*
805.4	Fort Benton	....	619.4	Boyd's Island	186
787.7	Marias River	17.7	600.9	Musselshell River	204.5
764.9	Little Sandy River	40.5	486.2	Fort Peck	319.2
756.4	Citadel Rock	49	468.6	Milk River	336.8
745.9	Cathedral Rock	59.5	453.4	Porcupine Creek	352
743.4	Hole in the Wall	62	373.4	Frenchmen's Point	432
731.4	Arrow River	74	355.8	Big Muddy River	449.6
725.3	Drowned Man's Rapids	80.1	321.9	Little Muddy River	483.5
723.1	Old Camp Cook	82.3	309.4	Fort Union	496
722.4	Judith River	83	305	Yellowstone River	500.4
718.8	Holmes Rapids	86.6	302.9	Fort Buford	502.5
707.6	Dauphin Rapids	87.8	267.8	Muddy River	537.6
693.7	Lone Pine Rapids	111.7	205	White Earth River	600.4
689.6	Sturgeon Island	115.8	186.4	Little Knife River	619
681.9	Cow Island	123.5	131.6	Little Missouri	673.8
671.4	Grand Island	134	108.4	Fort Berthold	697
665.3	Two Calf Island	140.1	84	Fort Stevenson	721.4
657.8	Emile or Harriett Island	147.6	60.4	Big Knife River	745
647.9	Little Rock Creek	157.5	52.5	Fort Clark	752.9
638.9	Carroll	166.5	....	Bismarck	805.4
621.7	Beauchamp's Creek	183.7			

REPORT OF A RECONNAISSANCE OF JUDITH BASIN, AND OF A TRIP FROM CARROLL TO FORT ELLIS, VIA YELLOWSTONE RIVER. BY LIEUT. R. E. THOMPSON.

FORT STEVENSON, DAK., *March* 8, 1876.

SIR: I have the honor to forward herewith a report of the reconnaissance of the Judth Basin, made during the past summer, in accordance with your orders, and an account of my subsequent return from Carroll, Mont., to Fort Ellis, by way of the Yellowstone River.

The trip to the Judith River, which was laid out as part of the summer's work, on condition that it could be completed before the close of navigation on the Upper Missouri, was ordered from the camp on Armell's Creek, September 11. Its object was the examination of the country in the vicinity of the Judith, with regard to its topographical features, to accurately locate its position, but more particularly to afford an opportunity for a thorough search for fossil remains in the cut banks of its valley, which offer so extensive an exposure. The party consisted of a sergeant and one private of the Engineer Battalion, charged with running the trail by compass and odometer; a detachment of a sergeant and seven privates of the Second Cavalry as escort; and Reynolds as guide.

Mr. G. B. Grinnell and Mr. Ludlow accompanied the party; the former interested in the palontology and zoology of the country. Sextant-observations were made by Mr. W. H. Wood whenever practicable.

Including myself, the party numbered fifteen men, all mounted, save the teamster, the sergant in charge of the odometer-cart, and the man charged with the care of the chronometers.

On the morning of September 12, the party was put *en route* across a stretch of rolling prairie country. The general course was toward Square Butte, a landmark in the vicinity of Benton, considerably west of the point to be reached; but it was deemed advisable from lack of knowledge of the country, and from the broken appearance to our right, to take the divide between Dog Creek and the Judith, and to follow this up till opportunity offered to descend to the valley of the latter stream near its mouth. The headwaters of Dog Creek were reached in the afternoon. Here I was joined by Reed, who had volunteered his services as guide. Camped at a pool near this creek.

In the morning (September 13) a course more to the north was taken, bearing nearly on Bear's Paw Mountains. The divide was kept from necessity, either valley being impassable for wagon. Shortly after leaving camp, the broken character of the Judith Bad Lands began to appear to our left and front.

For twenty miles back from the mouth of the stream, the country immediately tributary to it is washed and cut into the wildest and most rugged shapes. The soil is of that clayey character capable of supporting itself at steep inclines; and where ordina-

rily the drainage would be conducted in simple valleys or natural depressions, here gulches and ravines, with precipitous sides, are formed by the flow of the water. The worst of these were avoided, and to within ten miles of the mouth of the Judith our path was over a country such that a heavily-loaded wagon-train could have been conducted with but little difficulty.

The Judith and Dog Creeks from their sources converge gradually, and at their junction with the Missouri are but 3 miles apart. The valley of Dog Creek is broken in a manner similar to that of the Judith, and back 10 miles from their mouths this erosion, from long-continued action of water, has gone to such extent that the summit of the divide between these two streams is a simple backbone of a few feet in width, and the passage of this ridge with a single wagon, lightly loaded and conducted with care, nearly entailed the loss of the team. This difficult piece of road lasted but a few hundred yards. For 6 miles farther on the valleys keep apart and give a good stretch of prairie.

A descent into the valley of the Judith was made at a point 4 miles from its mouth. Camped on the river; abundance of wood; grazing poor.

The Judith is a swift-running stream, from 60 to 80 feet in width, and has a depth of water varying from 2 to 4 feet. Its sources in the Judith Mountains are clear, cold springs, but the character of the water changes completely in its course to the Missouri. Its temperature is very much increased, and a considerable amount of earthy matter is taken up and held in suspension. Though all its upper branches are plentifully stocked with trout, none of these fish were taken in the main stream. Its valley proper, from bluff to bluff, is about a mile wide, well timbered with a young growth of cottonwood. Scrub pines and cedars are sparsely scattered over the highlands, principally on the sides and at the heads of ravines. From the rate at which the wood is now being taken out for the supply of steamboats, the whole will be exhausted before many years.

September 14, moved camp half a mile down stream for better grazing; visited Fort Claggett, a small Indian trading-post on the Missouri, a short distance above the Judith. It consists of two log buildings facing each other, their ends joined by a stockade, with a small flanking arrangement at the alternate angles. A few Indians were seen about, their tepees standing near the fort.

From the ruins of old Camp Cooke, in the west angle between the Judith and Missouri, the plan of the post can be distinctly traced, some of the adobe walls still withstanding the effects of the weather.

The 15th and 16th were consumed in a vigorous search for fossils by nearly all the party. Observations were made by Mr. Wood.

On the night of the 16th, a courier arrived from Carroll, with orders from you for the return of the party. Preparations were made accordingly. As it is highly probable that a more lengthened search in this vicinity than our time had allowed would be richly rewarded, and, in order to afford every facility for the improvement of the time that could be gained, a mackinaw was procured, by which Mr. Grinnell, at whose disposal it was placed, with Messrs. Ludlow and Reynolds, was enabled to remain somewhat longer upon the ground, and then make Carroll by way of the Missouri as soon as the overland party.

The return trip began on the 17th. My old trail was necessarily taken for part of the way back, but, as soon as opportunity offered, a course to the east of it was taken; but little was gained by this, however, for from the nature of the ground I was compelled to pass near the old camp on Armell's Creek.

But little game was seen on the Judith. The Indians, as well as white men in that vicinity, kill for hides alone for purposes of trade. The consequence is very apparent. But three or four herds of buffalo and a few antelope were seen there, antelope becoming more plentiful as we left the river behind us.

Carroll was reached the afternoon of the 20th, the party by boat making the landing soon after.

This trip demonstrated the practicability of a wagon-road through the Judith Basin to the Missouri, though for general use a considerable amount of work would first need to be done.

The trail was carefully kept, the principal topographical features being sketched in. The data for the plotting of the course and the astronomical notes are already in your hands.

Every facility was afforded Mr. Grinnell in his collection of fossils. It is to be regretted that longer time could not have been taken in this work.

After the departure of the main party from Carroll for the East, it devolved upon me to conduct the transportation back to Ellis.

The party under my charge consisted of but two sergeants and ten privates of the Second Cavalry, and it was my intention to follow the road previously passed over by the party; but on my arrival at the forks of the Musselshell River I found a company of the Second Cavalry, commanded by Lieut. L. H. Jerome, under orders to scout the country east of the Crazy Mountains as far as the Yellowstone, and thence to return to Fort Ellis by way of that river.

Through the courtesy of Lieutenant Jerome, I was enabled to avail myself of the opportunity (which the small force at my disposal rendered it imprudent to attempt) to strike the Yellowstone at Big Timber Creek, a point within about 70 miles of that to which General Forsyth had ascended with his expedition in the spring.

Camp at the forks of the Musselshell was struck on the 28th of September, crossed to the south side of the Musselshell a mile below the forks, followed the general course of this stream for about 4 miles to the Little Elk—a well-wooded stream; crossed from this creek to the Big Elk (7 miles) in a course a little east of south, passed this stream, and three-quarters of a mile farther on a branch of the same. About 8 miles more of travel brought us to the Porcupine, (or American Fork.) Here camped.

Throughout this day's march, an exceedingly large number of antelope were observed, and at our camp on the Porcupine the woods and underbrush were alive with deer, showing in a very marked manner the absence of the skin-hunter.

September 29.—Traveled 7 miles to Summit Creek; 4 miles farther on crossed the Sweet Grass, a tributary to the Yellowstone. It is fed by springs and melted-snow from Crazy Mountain, and flows a volume of water nearly equaling that of the Musselshell.

Beyond this, several small streams were passed: Beaver Creek, standing in pools at this season, 2 miles; a branch of same, half a mile; 3 miles farther on, Williamson's Creek, and a mile from this, Burnt Creek, all emptying into the Sweet Grass.

The first crossing of Big Timber Creek was at 3 miles; we recrossed half a mile beyond, and camped on left bank. This stream is about 20 feet wide, clear and cold. The valley is *very* heavily timbered.

On the department maps, several small streams are noted as running into Big Timber from the north. There are no streams of any moment after passing Burnt Creek going south on this trail.

October 1.—Traveled down left bank of Big Timber for about 5 miles; crossed within half a mile of its mouth. Here observed indications of Indians, probably Crows.

Two large tripods, 20 feet or more in height, had been erected, and from the legs of these were suspended hundreds of moccasins, some of them beautifully beaded. It was remarkable that none of these moccasins were more than 5 inches in length; the most of them averaging about 3 inches: probably some offering, or medicine. Traveled up Yellowstone on its left bank. Little Timber about 4 miles and a half from Big Timber, about a third of the size of the latter; well wooded. The country between these two streams is very poor, almost no grazing; sage-brush being the main production. Half a mile farther on crossed a branch of Little Timber; the two unite about 300 yards from the Yellowstone. Three miles beyond, Cherry Creek. In succession, we passed Duck Creek 3 miles on, Hot Spring Creek 3 miles beyond, and Cold Spring Creek a mile beyond that. Went into camp on the Yellowstone near the latter.

October 2.—General course still along Yellowstone. Crossed Yellowstone 10 miles from camp at a point nearly opposite old Crow agency. The ford was very circuitous, ranging back and forth along the bars to avoid deep water. At this season, the greatest depth on this ford brings the water nearly to the wagon-body.

The old Crow agency, recently abandoned, is at the foot of the Yellowstone Mountains, opposite to, and about 4 miles from, the mouth of Shields's River. It consists of a collection of rude buildings, principally adobe. Recrossed the Yellowstone about 5 miles above the agency. There are two fords equally good, one above and one below "Benson's Ferry." Formerly, the passage of the stream at high water was made by a ferry-boat conducted by means of a cable stretched across the river. At the time of my crossing, the ferry was not in existence. Its place is marked by two stones on the left bank. Camped two miles below, just opposite one of the highest points of the Yellowstone Mountains, called Medicine Peak.

October 3.—After leaving camp, crossed Fleshman's Creek about 8 miles from Shields's River. Half a mile beyond is a small stream, which I followed up for about 12 miles, then pulled over a high divide; at this point the only difficult road was encountered. Across the divide, the head of the Middle Fork of the Gallatin River was struck, and a general course with that of the stream was followed to Fort Ellis.

In the progress up the Yellowstone River, a very noticeable feature presented itself; the change of the character of the country adjacent to it. Throughout its whole length on the lower stream, the elevations on either side never attain to more than the dignity of "buttes." But from the moment of passing Crazy Mountain, the scenery of the river becomes more in keeping with the grandeur to which it attains above.

Very respectfully, your obedient servant,

R. E. THOMPSON,
Second Lieutenant Sixth Infantry.

Capt. WILLIAM LUDLOW,
Corps of Engineers, Saint Paul, Minn.

ZOOLOGICAL REPORT, BY GEO. BIRD GRINNELL.

YALE COLLEGE, NEW HAVEN, CONN., *June* 1, 1876.

SIR: I beg leave to hand you herewith, as a partial report on the zoology of the region traversed by your expedition last summer, a list of the mammals and birds observed on the trip. In making out this list, I have taken care to give only such species as I actually saw and identified either in life or by their remains. I have added a list of such species as have been noticed in the immediate vicinity of the Yellowstone Park, combining the observations made by Mr. Merriam, of Hayden's survey, 1872, with my own during the past summer.

It may not be out of place here to call your attention to the terrible destruction of large game, for the hides alone, which is constantly going on in those portions of Montana and Wyoming through which we passed. Buffalo, elk, mule-deer, and antelope are being slaughtered by thousands each year, without regard to age or sex, and at all seasons. Of the vast majority of the animals killed, the hide only is taken. Females of all these species are as eagerly pursued in the spring, when just about to bring forth their young, as at any other time.

It is estimated that during the winter of 1874–'75 not less than 3,000 elk were killed for their hides alone in the valley of the Yellowstone, between the mouth of Trail Creek and the Hot Springs. If this be true, what must have been the number for both the Territories? Buffalo and mule-deer suffer even more severely than the elk, and antelope nearly as much. The Territories referred to have game laws, but, of course, they are imperfect, and cannot, in the present condition of the country, be enforced. Much, however, might be done to prevent the reckless destruction of the animals to which I have referred, by the officers stationed on the frontier, and a little exertion in this direction would be well repaid by the increase of large game in the vicinity of the posts where it was not unnecessarily and wantonly destroyed. At one or two points, notably Camp Baker, efforts have been made to drive off the skin-hunters, and with such success that the officers have very fine hunting within easy reach. The general feeling of the better class of frontiersmen, guides, hunters, and settlers, is strongly against those who are engaged in this work of butchery, and all, I think, would be glad to have this wholesale and short-sighted slaughter put a stop to. But it is needless to enlarge upon this abuse. The facts concerning it are well known to most Army officers and to all inhabitants of the Territory. It is certain that, unless in some way the destruction of these animals can be checked, the large game still so abundant in some localities will ere long be exterminated.

I am, sir, very respectfully, your obedient servant,

GEO. BIRD GRINNELL.

Col. WM. LUDLOW,
Chief Engineer Department Dakota, Saint Paul, Minn.

LIST OF MAMMALS AND BIRDS.

CHAPTER I.

MAMMALS.

FELIDÆ.

1. FELIS CONCOLOR, *Linn.*

Mountain Lion; Cougar.

Although not a common species, a few of these animals are killed in the mountains every winter.

The skins of the Cougar were formerly imported in large quantities from the east and from California for purposes of trade with the Indians. A few years since, a good skin was sometimes sold for seven or eight buffalo-robes; but at present they have little or no commercial value. A single individual of this species was seen by our party on the Yellowstone River, near the mouth of Alum Creek.

2. LYNX RUFUS, *Raf.*

Bay Lynx; Wildcat.

Very abundant in the mountains.

3. LYNX CANADENSIS, *Raf.*

Canada Lynx; Catamount.

Not a common species, though taken occasionally. I saw a few skins at Fort Peck, and was told that it was sometimes killed in the Yellowstone Park.

CANIDÆ.

4. CANIS OCCIDENTALIS, *Rich.*

Gray Wolf; Timber Wolf.

Although the Gray Wolf is always killed whenever the opportunity offers, it still exists in considerable numbers wherever the Buffalo are abundant. On the return march, just before entering the Judith Gap, I saw one pack of twelve, another of nine, and, besides these, many individuals singly or by twos and threes. Buffalo were very numerous here, and, although not much hunted, enough were killed to furnish abundant food for the wolves. This species was also abundant near the Judith River, and during the hours of darkness their howlings were heard almost constantly.

Wolfing, as it is called, is an established industry in Montana; and, being pursued only in winter, it gives employment and support to a large number of teamsters, steamboat-hands, and others who are necessarily idle at this season. The method is sufficiently simple. The wolfer, starting out, kills a deer, a buffalo, or some other large animal, and, thoroughly poisoning it with strychnine, leaves it for a day or two. When he returns to it, he finds from one to a dozen wolves, coyotes, and foxes lying dead about the carcass. As wolf-skins, large and small, *i. e.*, gray wolves and coyotes, bring $2.50 apiece at the trader's store, it is not unusual for two men to make $1,000 or $1,500 at this work in a winter.

Almost all the dogs seen among the Assinaboines, Crows, and Gros Ventres of the Prairie appeared to have more or less wolf-blood in their veins, and many of them would have been taken for true wolves had they been seen away from the Indian camps.

5. CANIS LATRANS, *Say.*

Prairie Wolf; Coyote.

This species is abundant between Carroll and Fort Ellis; being, I think, much more common on the prairie than in the mountains. I have always found it most numerous in a plain country, where there are deep-washed ravines, to which the animals may retire during the day, and in holes in the sides of which the young are brought forth. When searching for fossils in such places during the past summer, I have often come upon an old female lying at the mouth of a hole in the bank, and surrounded by her litter of from four to eight half-grown pups. At my appearance, the family would spring to their feet, stare at me for a few seconds, and then two or three would dart into the hole, as many wildly scramble up the bank, and the rest would start off up the ravine at a good round pace, looking back over their shoulders every few steps, as if there were a constant struggle between their fears and their curiosity.

A puppy, perhaps three months old, was captured while we were in camp on Crooked Creek. He had taken refuge in a hole in the bluffs, and was dug out and brought to camp. Although so young, he was utterly wild and vicious, snapping at any one that ventured to touch him, and refusing to eat. His unceasing efforts to escape were at length successful, and one morning we found that during the night he had gnawed off his fastenings and departed.

6. VULPES ALOPEX MACRURUS, *Baird.*

Prairie Fox.

This is an abundant species throughout the country traversed by our party. It is often found dead near the carcasses poisoned for wolves.

7. VULPES VELOX, *Aud. & Bach.*

Swift; Kit Fox.

This pretty little fox is common on the prairies of Dakota and Montana, and, as it is a species that has but few enimies, it is often quite tame. I have sometimes come upon one of these animals as it lay sleeping in the sun at the mouth of its burrow, and have been amused to see it, after a brief examination of me, stretch, yawn, and then with its tail held straight up in the air, and an appearance of the utmost unconcern, trot slowly into the hole. This has generally two openings; and sometimes, while you are examining one entrance, the Swift may be seen inspecting you from the other.

MUSTELIDÆ.

8. MUSTELA AMERICANA, *Turton.*

Marten.

The Marten is said to be quite abundant in the mountains of the Yellowstone Park, and it doubtless is found some distance down the Missouri River. I saw skins at Fort Peck which I was told had been taken in the immediate neighborhood.

9. PUTORIUS VISON, *Rich.*

Mink.

This species was quite abundant all through the mountains. Some very fine dark specimens were seen along Bridger Creek near Fort Ellis.

10. GULO LUSCUS, *Sabine.*

Wolverene; Skunk-bear.

No living individuals of this species were seen by any of the party; but we noticed their tracks quite often while in the park, and saw many skins in Bozeman. Hunters there informed me that they were seldom killed, except in the severest weather of the winter. In this region they were spoken of as the "Skunk-bear;" farther south they are called "Carcajou." The young, when first born, are said to be snow-white in color. Although this species is seldom found far from the mountains, an individual was killed during the winter of 1872–'73 near Fort Stevenson, on the Missouri River. It had probably wandered out on to the prairie from the high Bad Lands of the Little Missouri.

11. LUTRA CANADENSIS, *Sab.*

Otter.

Although nowhere a very abundant species, the Otter occurs perhaps as frequently on the Missouri River as on the purer mountain-streams. The furs taken on this river, however, are by no means so valuable as those which come from the mountains, being much lighter in color and less glossy. This difference is regarded by trappers and dealers in furs to be due to the muddy character of the Missouri water. Whether this be the case, or whether it is merely an exemplification of the law which obtains with regard to the birds and mammals of the plains as contrasted with those of the mountains, I am unable at present to determine. It seems quite possible, however, that the former explanation is the true one, since animals like the Otter and Beaver, to which latter the above remarks also apply, from the conditions of their lives are but slightly exposed to the modifying influences which act on animals living on the uplands and more or less diurnal in their habits.

The fur of the Otter is highly prized by the Indians; being used by them to tie up the hair, to ornament their "coup-sticks," to cover bow-cases and quivers, and for a variety of other purposes.

12. MEPHITIS MEPHITICA, *Baird.*

Skunk.

This species is exceedingly abundant throughout Eastern Montana. While ascending the Missouri River, we often saw them on the low benches of alluvium left bare by the rapid falling of the waters. Having slipped or climbed down the almost vertical banks to get to the water, they seemed unable to retrace their steps, and could only escape from their prison by swimming.

At Camp Lewis these animals were so numerous as to have become a terrible nuisance. Mr. Reed, the post-trader, told me one morning that during the previous night he had been obliged to rise four times to kill Skunks.

13. TAXIDEA AMERICANA, *Baird.*

Badger.

The Badger was quite common all through the prairie country over which we passed, but was most often seen in the vicinity of the prairie-dog towns. It is a slow animal, and may easily be overtaken by a man on foot. If unable to reach its hole in time to escape, it will turn and rush toward its pursuer in the most courageous manner; snapping and snarling in such a way as to inspire one with a wholesome respect for it.

URSIDÆ.

14. PROCYON LOTOR, *Storr.*

Raccoon.

This species occurs occasionally along the Missouri River.

15. URSUS HORRIBILIS, *Ord.*

Grizzly Bear.

The Grizzly is rather common in some localities along the Missouri; and from the upper deck of the steamer I saw three one evening digging roots in a wide level bottom. In the Bridger Mountains and in the Yellowstone Park they were numerous, so much so that we would often see several sets of fresh tracks in a morning's ride. From their abundance in the vicinity of Fort Ellis and Bozeman, it was evident that they were not much disturbed by hunters.

In Bozeman, I was shown two cubs about six months old; and two more sullen and vicious little brutes I never saw. A Black Bear cub of about the same age was as friendly and playful as a puppy; but no one dared to venture within reach of the Grizzlies.

But little seems to be known about the breeding-habits of this bear. It is pretty well established, however, that the young are brought forth about the 15th of January, and that they are then very small, scarcely larger than new-born puppies.

16. URSUS AMERICANUS, *Pallas.*

Black Bear.

Not nearly so common as the preceding species. Only one living specimen was seen. At a ranch near the bridge over the Yellowstone River, however, I was shown a single skin of the so-called Cinnamon Bear, which, I was told, had been taken in the Park.

SCIURIDÆ.

17. SCIURUS HUDSONIUS, *Pallas.*

Red Squirrel; Pine Squirrel.

Red Squirrels were abundant wherever pine timber was found. In the mountains, they seem to feed chiefly on the seeds of the pine; and I frequently came upon little heaps of cones gathered together by the squirrels just as they collect nuts in the East. Most specimens taken in the Yellowstone Park seem to be referable to var. *Richardsonii*, but several killed in the Fire Hole Valley are not to be distinguished from ordinary Connecticut specimens.

18. TAMIAS QUADRIVITTATUS, *Rich.*

Missouri Ground Squirrel.

This pretty little squirrel seems equally at home among the most desolate Bad Lands, where no vegetation is to be found save a few straggling sage-bushes, and amid the dense pine forests and luxuriant undergrowth of the mountains. They are very gentle and unsuspicious, and would play about in the most unconcerned manner while I was standing within a few feet of them.

Although by no means tree-climbers, in the strict acceptation of the term, I often saw them, while at play or when frightened, ascend the pines to a height of 20 or 30 feet. It would seem that they are not exclusively vegetarian in their diet; for I interrupted one of them while making a meal of the dried carcass of a *Hesperomys*. It sat up, holding the food in its fore feet in the ordinary manner, and gnawing the meat from the back and shoulders. No doubt, in some localities it feeds, partially at least, on grasshoppers, as many of the small rodents of the West are known to do.

19. Spermophilus tridecim lineatus, *Mitchell.*

Striped Prairie Squirrel.

This species was common everywhere on the prairies. When anything unusual attracts its attention, it raises itself up on its haunches to examine the object of its curiosity. As this approaches, the squirrel gradually lowers itself until at last it is quite flattened out upon the ground. In this position, if the eye is removed from it for a moment, it is very difficult to find it again, as its colors harmonize admirably with the yellowish gray of the soil.

20. Spermophilus richardsonii, *Cuv.*

Richardson's Ground Squirrel.

This species was not seen until after we had passed Camp Lewis in Montana. Along the North Fork of the Musselshell River it was abundant in the valley, and it was observed in considerable numbers about Camp Baker and Fort Ellis.

In their habits they resemble the Prairie-dog (*Cynomys*) more nearly than any other species with which I am acquainted. They live in communities, act as do the Prairie-dogs when approached, and are equally hard to secure when shot near the entrance of their burrows. A young one, killed with a charge of fine shot at short range, moved himself over two feet along the smooth surface of a flat rock, on which he had been lying when shot, by convulsive pushes of his hind feet. After I had taken him in my hand, these kickings continued for half a minute or more, although the animal could not have been conscious after the shot struck him.

I several times saw the young of this species playing with one another very prettily. One standing over the other would hold him down and pretend to bite his head and neck, just as we often see young puppies play together.

At Camp Baker, there were many of these animals in and about our camp, and they soon became very tame. Often they would come to the open tent-door, and, sitting on their haunches, would watch the occupants with an appearance of the greatest curiosity. We often tried to catch them alive, but were never successful. They would always manage to slip into some hole that we did not know of, just as our hands were on them. Between Fort Ellis and Bozeman there is quite a large settlement of these animals, and they were more tame here than at any other locality where we met with them.

21. Cynomys ludovicianus, *Baird.*

Prairie Dog.

Quite abundant on the plains near the foot of the mountains.

22. Arctomys flaviventer, *Bach.*

Western Woodchuck.

Common in the mountains, but rather a shy species, more often heard than seen.

23. Castor canadensis, *Kuhl.*

Beaver.

While ascending the Missouri, we saw the houses and "slides" of the Beaver very frequently, and often, just at evening, the animals themselves were observed, sitting on the banks gazing at the steamer, or feeding on the tender shoots of the cottonwood and willow. They were by no means shy, and would sometimes permit the vessel to pass within a few yards of them without taking to the water.

The streams in the mountains through which we passed were sometimes dammed by the beavers for miles, and the backwater spreading out over the level valleys makes wide ponds. These in the course of time are partially filled up with the mud carried down by the stream, and when this takes place are deserted by the beavers, which move away and build another dam somewhere else. As the pond fills, a rank growth of rushes and underbrush springs up, and before long what was a pretty little lake has become an impassable morass.

The value of the fur of the Missouri River Beaver is diminished by the same causes spoken of in reference to that of the Otter.

SACCOMYIDÆ.

24. Thomomys talpoides, (*Rich.*) *Baird.*

Gopher.

An individual of this species was taken among the high mountains near the head of Gardiner's River. It was running over the snow-drifts when captured.

MURIDÆ.

25. Zapus hudsonius, *Coues.*

Jumping Mouse.

This species was observed several times in the Bridger Mountains, and again on Cascade Creek near the Yellowstone River.

26. Mus decumanus, *Pallas.*

Brown Rat.

The common wharf-rat is sufficiently abundant in all the settlements on the Missouri River to be a great nuisance and to do considerable damage. In the trader's store at Fort Peck they were very numerous, so much so that the trader told me that he had recently poisoned one hundred and fifty in one week.

27. Mus musculus, *Linn.*

House Mouse.

Abundant in towns and large settlements, but in isolated ranches replaced by the following species.

28. Hesperomys leucopus sonoriensis, *LeConte.*

Western White-footed Mouse.

This species was very abundant along the North Fork of the Musselshell River and along the Yellowstone. In many places they had deserted the woods and fields and taken to the ranches, where they are quite as annoying as the common House Mouse.

29. Arvicola riparia, *Ord.*

Meadow Mouse.

Very common along the Yellowstone River.

30. Fiber zibethicus, (*L.*) *Cuv.*

Muskrat.

Abundant on streams flowing into the Missouri.

HYSTRICIDÆ.

31. Erithizon epixanthus, *Brandt.*

Yellow-haired Porcupine.

Quite common along the Missouri and in the "bottoms" of streams flowing into that river. We saw signs of its presence also in the National Park along the Yellowstone River.

LEPORIDÆ.

32. Lepus campestris, *Bachman.*

Prairie Hare.

This species is very abundant in some localities, while in others, quite as favorable for it, it is not found at all. In fact, the abundance or scarcity of the Prairie Hare in any district depends almost altogether on the number of wolves to be found in the same tract of country. Where all the coyotes and gray wolves have been killed or driven off, the hares exist in great numbers; but where the former are abundant, the latter are seldom seen. We saw none near the Missouri River, where the buffaloes, and consequently the wolves, were numerous; but at Camp Baker, where there were scarcely any wolves, the hares were very common.

33. Lepus artemisia, *Bachman.*

Sage Rabbit.

Very abundant west of the Missouri in suitable localities, but its numbers controlled by the same causes spoken of in regard to the preceding species.

CERVIDÆ

34. ALCE AMERICANA, *Jardine.*

Moose.

This species is quite abundant in suitable localities in the Yellowstone Park, although, like all the large game, it has been driven away from the neighborhood of the trail by the constant passage of travelers. We saw signs of its presence in the Bridger Mountains, and were told that there was a famous country for Moose about fifteen miles from the mouth of Trail Creek.

The only living specimen that we saw was a young calf that had been captured by the son of a settler when it was but a few days old. When seen by us, it was probably about three months old, and was a most grotesque object. It was very tame, and would come at the call of its owner.

35. CERVUS CANADENSIS, *Erxleben.*

Elk.

Elk were rather abundant all through the country which we traversed. They were seen in considerable numbers along the Missouri River, among the Bridger Mountains, and in the Yellowstone Park. Those killed early in September, at the commencement of the rutting season, were fat and well flavored, furnishing us with delicious meat.

The Elk rut in September, and the young are brought forth late in May or early in June.

The "whistling" of the Elk is heard only for a few days during the early part of September. It is made up of several parts, and is so peculiar a cry that it can hardly be described, much less imitated. The first part consists of a prolonged, shrill whistle, which seems to come to the hearer from a long distance, even though the animal uttering it be quite near at hand. This is followed by a succession of short grunting brays or barks, three or four in number, and the call is completed by a low, smooth bellow. Sometimes the whistle is sounded without the succeeding parts. Withal, the cry is an odd one, and one that once heard will always afterward be recognized.

36. CERVUS VIRGINIANUS, *Boddaert.*

Red Deer; White-tailed Deer.

This species was by no means abundant in the country through which we passed. We saw a few along the Missouri, and I noticed one in the Judith Mountains; but on the whole they were seldom seen.

37. CERVUS MACROTIS, *Say.*

Mule Deer; Black-tailed Deer.

The Black-tailed Deer, as it is usually called in the Missouri River country, is an abundant species in Eastern Montana. It is quite unsuspicious, and, except where it has been much hunted, will often permit the hunter to fire two or three shots at it before it takes to flight. This species, and the same may be said of all large game in that section of the country, is at present most recklessly slaughtered for the hides alone. It will soon, unless some means are taken for its protection, be unknown in the regions where it is now so plentiful.

ANTELOPIDÆ.

38. ANTILOCAPRA AMERICANA, *Ord.*

Prong-horned Antelope.

Everywhere abundant on the plains, the Antelope forms one of the most pleasing and attractive features of those barren wastes. Although where they have been much hunted they are difficult to approach, they are very unsuspicious and curious where they have been accustomed to seeing and mixing with large animals. About Camp Baker, and between that post and Fort Ellis, there are large droves of cattle which roam at will over the prairie. The Antelope become used to the presence of these large animals, and are often seen mingling with the herds when feeding or resting.

One day while out from Camp Baker in search of Tertiary fossils, my companion and myself stopped on the borders of a little stream to rest and cook some food. The saddle-horses and pack-mule were picketed near at hand; a fire had been kindled, and we were discussing some broiled venison, when two antelope suddenly appeared over the brow of a bluff about seventy-five yards distant. On seeing us, they scarcely hesitated, but trotted gracefully on toward us, and would, I have no doubt, have come quite up to us, if it had not been that my companion shot them both when they were still about forty yards distant. When in the buffalo country, Antelope, if the

wind was right, would often approach very near me, several times coming to within a few yards of where I was standing.

It is well known that the female Antelope sometimes has horns and is sometimes without them. Observations extended over several years, together with the testimony of several plainsmen, among them Charles Reynolds, a hunter of seventeen years' experience and a man of close observation, lead me to conclude that the horned does are always barren. I have myself examined a great number of doe-antelopes with and without horns, and have never seen one of the former class that gave evidence of having produced or being about to have young. Nor have I ever seen a hornless doe that was barren. The horns on the does vary from one to three inches in length, have no prong, and are soft and easily bent. Their length no doubt depends in a measure upon the age of the animal. Those that I have seen lack the hard bony core which is found in the horns of the perfect males.

The barren does are always fat, and on this account are, when it is possible, selected by the hunter in preference to the other members of the herd.

OVIDÆ.

39. OVIS MONTANA, *Cuv.*

Bighorn; Mountain Sheep.

The Bighorn occurs in considerable numbers in the Judith Mountains and in the Yellowstone Park, away from the trail; but they are so wary that they are not often seen. As is well known, they affect the most rugged and barren country, and they are perhaps more plentiful in the Bad Lands of the Judith and Missouri Rivers than anywhere else.

On the Cone Butte and Sweet Grass Mountains, which are covered for half their height with a talus of platter-like blocks of trachyte, the sheep in their passage up and down the sides of the hills have worn regular paths among and over the loose blocks, and it is only by following these paths that the ascent can be made on the east and south.

BOVIDÆ.

40. BOS AMERICANUS, *Gmelin.*

Buffalo; Bison.

No Buffalo were seen while we were ascending the Missouri River until just before we reached Carroll. From that place westward, they were occasionally observed until we reached the Judith Gap, although, owing to the presence in the region through which we were passing of the Sioux and Crows, they were not abundant. On our return march we saw great numbers of them before reaching the Gap, but none afterward until we were quite near the Missouri.

The statement that the herds of bulls that are everywhere met with during the autumn consist of individuals driven away from the main herd by their stronger rivals may, I think, be doubted. It is said that these assemblages are not seen in spring before the rutting-season. It seems more probable that during the late summer and autumn, many of the old and strong bulls, exhausted by the fatigues of the rutting-season, thin in flesh, and generally run down, are unable to keep up with the active and constantly-moving herd of cows and young animals, and devote all their energies to recruiting for the winter. Early in the spring they rejoin the herd and remain with it until the end of July.

During the past autumn the Buffalo have proceeded down the Missouri River much farther than is usual. They have been quite numerous a few miles north of Fort Berthold, Dakota, and a few stragglers have been seen near Painted Woods, about twenty-five miles above Bismarck.

The so-called "Mountain Buffalo" was abundant in the Yellowstone Park.

CHAPTER II.

BIRDS.

TURDIDÆ.

1. TURDUS MIGRATORIUS, *Linn.*

Robin.

This species was abundant along the Missouri River, and was also seen in considerable numbers in the mountains about Camp Baker and in the Yellowstone Park.

2. TURDUS SWAINSONI, *Cab.*

Olive-backed Thrush.

Quite common along the Missouri above Bismarck.

3. OREOSCOPTES MONTANUS, (*Towns.*) *Bd.*

Mountain Mockingbird.

I first saw this species on Little Crooked Creek, 13 miles west of Carroll. It was abundant, and doubtless had bred there, as I took some very young birds. It was generally started from the ground, whence it would fly to the top of some little sage-bush; where it would sit jerking its tail and constantly uttering low cries of anxiety. They were quite shy, and I was often obliged to follow them for some distance before I could secure them.

This species was abundant in the valley of the Yellowstone River.

4. MIMUS CAROLINENSIS, (*Linn.*) *Gray.*

Catbird.

Quite common along the Missouri River, and very abundant in the Yellowstone Park and in the mountains generally.

5. HARPORHYNCHUS RUFUS, (*Linn.*) *Cab.*

Brown Thrush; Thrasher.

This species was seen occasionally in the Missouri River bottom.

CINCLIDÆ.

6. CINCLUS MEXICANUS, *Sw.*

Water-ouzel; Dipper.

On Cascade Creek, near the Upper Falls of the Yellowstone, we first met with this interesting species. Although tolerably familiar with the accounts of its habits given by various authors, I must confess to having experienced a ludicrous feeling of astonishment the first time I saw the bird walk unconcernedly down a sloping rock until its head disappeared under the water. It repeated this performance several times, occasionally rising to the surface as if forced up by the water, and then immediately diving again. When carried down a few yards by the force of the current, it would fly a short distance up the stream and dive from the wing.

With the help of a good glass I saw from the top of the cañon two of these little birds flying about over the river where it boiled and surged along below the Lower Falls.

SAXICOLIDÆ.

7. SIALIA ARCTICA, *Sw.*

Arctic Bluebird; Western Bluebird.

One of the most abundant birds in the wooded region through which we passed. It was especially numerous in the Yellowstone Park late in August and early in September, when it formed a large division of the army of small birds that were being constantly started from the ground.

PARIDÆ.

8. PARUS ATRICAPILLUS SEPTENTRIONALIS, (*Harris*) *Allen.*

Long-tailed Chickadee.

Common along the Missouri River and in the mountains.

9. PARUS MONTANUS, *Gamb.*

Mountain Chickadee.

A few birds of this species were seen searching for food among the pines that grow among the Bad Lands near the mouth of the Judith River. In habits, they seemed to resemble closely the preceding species; but the note was slightly different, being more slowly uttered, almost drawled in fact.

SITTIDÆ.

10. SITTA CAROLINENSIS ACULEATA, (*Cass.*) *Allen.*

Slender-billed Nuthatch.

Common in the Yellowstone Park and in the mountains toward the Missouri River.

TROGLODYTIDÆ.

11. Salpinctes obsoletus, (*Say*) *Cab.*

Rock Wren.

Very abundant in the Bad Lands along the Missouri and among the sandstone bluffs near the Judith Mountains. These birds were also common in the Little Belt Mountains, near White-tailed Deer Creek, darting about among old stumps and wood-piles, just as they do among the bluffs of the Bad Lands. A nest found near Haymaker's Creek was nothing more than a short burrow under a flat rock. The little chamber at the end contained three nearly full-grown young.

12. Troglodytes aëdon parkmanni, (*Aud.*) *Coues.*

Western House Wren.

Abundant on the Missouri near Bismarck.

13. Cistothorus palustris, (*Wils.*) *Baird.*

Long-billed Marsh Wren.

This species was seen but once, on a reedy slough near the bridge over the Yellowstone River.

ALAUDIDÆ.

14. Eremophila alpestris leucolæma, (*Forst.*) *Coues.*

Horned Lark; Shore Lark.

Abundant everywhere on the plains.

MOTACILLIDÆ.

15. Anthus ludovicianus, (*Gm.*) *Licht.*

Titlark.

A single individual of this species was seen among the snows on the highest point of the Bridger Mountains.

16. Neocorys spraguei, (*Aud.*) *Scl.*

Missouri Skylark.

This little-known bird was not uncommon between Camp Lewis and Camp Baker. It was most often seen in the road searching for food, and, when alarmed, running along in the ruts as the Shore Larks are often seen to do. It was usually seen in company with these latter, and seems somewhat to resemble them in its habits.

SYLVICOLIDÆ.

17. Dendrœca æstiva, (*Gm.*) *Baird.*

Yellow Warbler; Summer Yellowbird.

Abundant and breeding along the Missouri River.

18. Dendrœca audubonii, (*Towns.*) *Baird.*

Audubon's Warbler.

A family of this species, the young of which had but just left the nest, was seen among the pines near the Yellowstone bridge.

19. (?) Seiurus aurocapillus, (*Linn.*) *Sw.*

Golden-crowned Thrush.

The characteristic song of this species was often heard along the Missouri; but I was unable to secure any specimens, or even to see the birds.

20. Geothlypis trichas, (*Linn.*) *Cab.*

Maryland Yellowthroat.

Seen quite often along the Missouri.

21. Geothlypis philadelphia macgillivrayi, (*Wils.*) *Allen.*

Western Mourning Warbler.

A female of this species was found dead on the shore of the Yellowstone Lake.

22. Icteria virens, (*Linn.*) *Baird.*

Yellow-breasted Chat.

Abundant along the Missouri River. Its familiar notes were heard whenever we passed a wooded bottom, and its curious antics often seen.

23. Setophaga ruticilla, (*Linn.*) *Sw.*

Redstart.

Seen on several occasions in the Missouri River bottom.

TANAGRIDÆ.

24. Pyranga ludoviciana, (*Wils.*) *Bon.*

Louisiana Tanager.

Observed quite frequently in the Yellowstone Park.

HIRUNDINIDÆ.

25. Hirundo horreorum, *Barton.*

Barn Swallow.

Abundant throughout the region which we traversed.

26. Hirundo thalassina, *Sw.*

Violet-green Swallow.

Very numerous about Fort Ellis, and more or less abundant throughout the Yellowstone Park.

27. Petrochelidon lunifrons, (*Say*) *Scl.*

Cliff Swallow.

Extremely abundant along the Missouri River, breeding on many of the high bluffs between which it flows. They were also common in the mountains, and especially so about Camp Baker.

Early one morning late in July, while traveling along the road near the Judith Mountains, I was surprised to see great numbers of these birds feeding on the ground. A little investigation showed me that they were picking up insects that had been chilled by the severe frost of the previous night, and were as yet unable to fly.

28. Cotyle riparia, (*Linn.*) *Boie.*

Sand Martin; Bank Swallow.

Observed in large numbers on the Missouri River; often breeding in the same bluffs to which the preceding species had attached their nests.

29. Progne subis, *Baird.*

Purple Martin.

Abundant in the mountains, where it breeds.

AMPELIDÆ.

30. Ampelis garrulus, *Linn.*

Bohemian Waxwing.

At Camp Baker I saw the remains of an individual of this species, which, I was informed by Major Freeman, had been taken there in winter. It is said to be common there at that season.

31. Ampelis cedrorum, (*Vieill.*) *Gray.*

Cedar-bird.

Quite common along the Missouri.

LANIIDÆ.

32. Collurio ludovicianus excubitoroides, (*Sw.*) *Coues.*

White-rumped Shrike.

Common along wooded ravines on the plains west of the Missouri.

FRINGILLIDÆ.

33. CARPODACUS CASSINI, *Baird.*

Cassin's Purple Finch.

A single individual of this species was taken at the Mud Volcano in the Yellowstone Park.

34. LOXIA CURVIROSTRA AMERICANA, (*Wils.*) *Coues.*

Red Cross-bill.

This species was found in great numbers near the Falls of the Yellowstone in August. It had undoubtedly bred in the immediate vicinity, as I saw old birds feeding young just from the nest. Their food seemed to consist entirely of the seeds of the pine. The males uttered almost constantly a short monotonous whistle.

35. CHRYSOMITRIS PINUS, (*Wils.*) *Bp.*

Pine Finch.

Though this species was noticed several times while in the park, it did not seem to be common there. The birds were seen among the pines or else feeding on thistle-blows, after the manner of *C. tristis.*

36. CHRYSOMITRIS TRISTIS, (*Linn.*) *Bp.*

Yellow-bird; Thistle-bird.

Abundant along the Missouri and on the plains near the mountains.

37. PLECTROPHANES ORNATUS, *Towns.*

Chestnut-collared Longspur.

Abundant, and one of the most characteristic birds of the high plains. The most eastern point at which I saw it was Jamestown, Dak. From that place west it was more or less common until we left the plain country. Late in July I took, near Box Elder Creek, young birds that had but just left the nest.

38. PLECTROPHANES MACCOWNII, *Lawr.*

Maccown's Longspur.

Abundant, breeding on the plains in company with the preceding. I secured many fully-fledged birds of the year late in July.

39. PASSERCULUS SAVANNA, (*Wils.*) *Bp.*

Savannah Sparrow.

Quite common about Camp Baker.

40. POOCÆTES GRAMINEUS CONFINIS, (*Gm.*) *Baird.*

Grass Finch; Bay-winged Bunting.

Abundant everywhere on the plains.

41. COTURNICULUS PASSERINUS PERPALLIDUS, (*Wils.*) *Ridgway.*

Yellow-winged Sparrow.

Common on the plains near the Missouri.

42. MELOSPIZA MELODIA FALLAX, (*Wils.*) *Ridgway.*

Western Song Sparrow.

Common in the mountains, especially in low brush along the banks of streams, but so shy as to be quite difficult of approach.

43. JUNCO OREGONUS, (*Towns.*) *Scl.*

Oregon Snowbird.

Very abundant in the mountains of the Yellowstone Park.

44. SPIZELLA MONTICOLA, (*Gm.*) *Baird.*

Tree Sparrow.

Three or four individuals of this species were seen in the Bridger Mountains early in September.

45. SPIZELLA SOCIALIS ARIZONÆ, (*Wils.*) *Coues.*

Western Chippy.

Abundant in the mountains.

46. SPIZELLA PALLIDA, (*Sw.*) *Bp.*

Clay-colored Sparrow.

Abundant on the plains in bushy ravines and along the river-bottoms.

47. ZONOTRICHIA LEUCOPHRYS, (*Forst.*) *Sw.*

White-crowned Sparrow.

This species was abundant in the Yellowstone Park. It was seen during August and September in small flocks of ten or twelve individuals, old and young, feeding on the ground in company with *S. arctica* and a host of small sparrows.

48. CHONDESTES GRAMMACA, (*Say*) *Bp.*

Lark Finch.

Very abundant on the plains near the Missouri River and westward.

49. CALAMOSPIZA BICOLOR, (*Towns.*) *Bp.*

White-winged Blackbird.

Very abundant on the plains, especially in somewhat broken country along ravines and dry water-courses, and also in the neighborhood of isolated buttes. I found it breeding near Little Crooked Creek.

50. EUSPIZA AMERICANA, (*Gm.*) *Bp.*

Black-throated Bunting.

A breeding female taken in the Missouri River bottom near Bismarck early in July was the only individual of this species seen.

51. CYANOSPIZA AMŒNA, (*Say*) *Baird.*

Lazuli Finch.

This beautiful species was abundant along the Missouri River bottom.

52. PIPILO MACULATUS ARCTICA, (*Sw.*) *Coues.*

Arctic Towhee.

Abundant, breeding in the Missouri River bottom, and often seen about Camp Baker.

ICTERIDÆ.

53. DOLICHONYX ORIZIVORUS, (*Linn.*) *Sw.*

Bob-o-link; Rice-bird.

This species was breeding in large numbers in the wide river-bottom near Bismarck when we passed through early in July. I saw none except here during the trip.

54. MOLOTHRUS PECORIS, (*Gm.*) *Sw.*

Cow-bunting.

Abundant everywhere.

55. AGELÆUS PHŒNICEUS, (*Linn.*) *Vieill.*

Red-winged Blackbird.

Noticed on several occasions along the Missouri River.

56. STURNELLA MAGNA NEGLECTA, (*Linn.*) *Allen.*

Western Meadow Lark.

Abundant all through the open country. We heard their sweet songs all through the summer and as late as September 18.

57. SCOLECOPHAGUS CYANOCEPHALUS, (*Wagl.*) *Cab.*

Blue-headed Grakle.

I found this species very abundant near Carroll, and, in fact, everywhere on the plains. At Little Crooked Creek, their nests were found placed on little "greasewood" bushes only two or three feet in height. The young were most of them so well grown at this time (July 15) that they would leave the nest at my approach and fly a few yards to another bush, where they would sit uttering the sharp cry that we hear from all young blackbirds at that age. When I approached the nests or young, flocks of a dozen or more old birds would fly over me uttering constantly cries of anxiety.

About Camp Baker, they were very numerous; the flocks being so large as to fairly blacken the ground where they alighted. The birds were familiar enough and readily ventured up to our tent doors.

CORVIDÆ.

58. Corvus corax, *Linn.*

Raven.

Rather common on the plains west of Carroll.

59. Corvus americanus, *Aud.*

Crow.

Extremely abundant on the streams flowing out of the Sweet Grass Hills. They were breeding here in the tall undergrowth that fringed Box Elder and Armell's Creek, and on the return march were seen in large flocks feeding on the dead buffalo that strewed the prairie. It is hardly necessary to remark that they were very tame, in striking contrast to their eastern relatives.

60. Picicorvus columbianus, (*Wils.*) *Bp.*

Clark's Crow.

I first noticed this species near Camp Baker, but it did not become very abundant until we reached the Yellowstone River on our road to the park. Its striking plumage and loud harsh voice makes this bird one of the most noticeable features of the animal life of this region.

61. Pica melanoleuca hudsonica, (*Sab.*) *Coues.*

Magpie.

Abundant everywhere in the mountains, and universally execrated by hunters and trappers on account of the injury it does in winter to the fresh skins that are stretched out to dry, and the annoyance it causes to their sore-backed animals.

62. Cyanurus stelleri macrolophus, (*Baird*) *Allen.*

Long-crested Jay.

Abundant from the Bridger Mountains through the Yellowstone Park. In habits this species resembles most closely *C. cristatus;* but its notes are quite different, being harsh and grating, more like those of *P. columbianus.*

63. Perisoreus canadensis capitalis, *Baird.*

Gray Jay.

I found this species extremely abundant all through the mountains of the Yellowstone Park. They are noisy, restless birds, continually passing to and fro among the branches of the pines with easy, graceful movements. They are at all times bold and even impudent, remaining in the trees beneath which we encamped, and frequently descending to the ground within a few feet of some one of the party to pick up a piece of meat or a crumb of bread. When a morsel of food has been secured, it is taken to a low limb and there leisurely broken up and devoured.

This species is said to cause considarable annoyance to trappers by removing the bait from their mink and marten traps.

TYRANNIDÆ.

64. Tyrannus carolinensis, (*Gm.*) *Temm.*

Kingbird.

Abundant along the Missouri and on the plains of the West.

65. Tyrrannus verticalis, *Say.*

Arkansas Flycatcher.

Abundant along the Missouri and on the plains.

66. Sayornis sayus, (*Bp.*) *Baird.*

Say's Flycatcher.

I saw but two or three individuals of this species, all of them near Crooked Creek.

67. Contopus virens richardsonii, (*Sw.*) *Allen.*

Western Wood Pewee.

I frequently noticed this species while in the Geyser Basins, but did not observe it at any other point on the route. In the Lower Geyser Basin, I saw one of these birds taken by a Sharp-shinned Hawk, which was immediately attacked with the utmost fury by another Pewee. The latter kept up the chase for a considerable distance finally following his enemy into the woods.

CAPRIMULGIDÆ.

68. CHORDEILES VIRGINIANUS HENRYI, (*Gm.*) *Coues.*

Western Nighthawk.

This species was common on the plains. Near Little Crooked Creek, late in July, I took a female sitting on two eggs, which were far advanced towards hatching.

ALCEDINIDÆ.

69. CORYLE ALCYON, (*Linn.*) *Boie.*

Kingfisher.

Abundant on all streams which we passed, though apparently less common on the Missouri below Carroll than elsewhere. This is probably due to the fact that the river below this point is very muddy, and the Kingfishers are hence unable to find and pursue their prey as successfully as in the clear streams of the mountains.

CUCULIDÆ.

70. COCCYZUS ERYTHROPHTHALMUS, (*Wils.*) *Bp.*

Black-billed Cuccoo.

Common along the Missouri, at least as far as Wolf Point, 40 miles below Fort Peck

PICIDÆ.

71. PICUS VILLOSUS HARRISII, (*Linn.*) *Allen.*

Harris' Woodpecker.

Seen once in the Little Belt Mountains near Camp Baker.

72. PICUS PUBESCENS, *Linn.*

Downy Woodpecker.

Occasionally noticed in the Yellowstone Park near the bridge.

73. SPHYRAPICUS THYROIDEUS, (*Cass.*) *Baird.*

Black-breasted Woodpecker.

Observed but once, near Tower Creek in the Yellowstone Park.

74. MELANERPES ERYTHROCEPHALUS, (*Linn.*) *Sw.*

Red-headed Woodpecker.

Very common wherever there was timber.

75. MELANERPES TORQUATUS, (*Wils.*) *Bp.*

Lewis' Woodpecker.

We first saw this species in the mountains near Camp Baker, where it was quite abundant. It was afterward seen in considerable numbers near the mouth of Trail Creek, and along other little timbered streams running into the Yellowstone River. These birds were several times seen searching for food upon the ground after the manner of *Colaptes.*

76. COLAPTES AURATUS, (*Linn.*) *Sw.*

Golden-winged Woodpecker; Flicker.

Abundant along the Missouri River, at least as far up as Fort Buford.

77. COLAPTES MEXICANUS, *Sw.*

Red-shafted Woodpecker.

Abundant about Camp Baker and in the Yellowstone Park.

STRIGIDÆ.

78. BUBO VIRGINIANUS, (*Gm.*) *Bp.*

Great Horned Owl.

Seen once near Carroll.

79. OTUS PALUSTRIS, (*Bechst.*) *Gould.*

Short-eared Owl.

Common on the plains.

80. SPEOTYTO CUNICULARIA HYPOGÆA, (*Bp.*) *Coues.*

Burrowing Owl.

Seen occasionally on the plains.

FALCONIDÆ.

81. CIRCUS CYANEUS HUDSONIUS, (*Linn.*) *Schl.*

Marsh Hawk.

Very common throughout the country which we passed over.

82. NISUS FUSCUS, (*Gm.*) *Kaup.*

Sharp-shinned Hawk.

This species was seen but twice; one specimen having been taken on the shores of the Yellowstone Lake, and another observed in the Lower Geyser Basin.

83. NISUS COOPERI, (*Bp.*) *Ridgway.*

Cooper's Hawk.

A single individual of this species was seen while we were ascending the Missouri.

84. FALCO LANIARIUS POLYAGRUS, (*Cass.*) *Ridgway.*

American Lanner Falcon.

This species, although not common in the country through which we passed, was occasionally seen, and no doubt bred on the mountains. I felt quite sure that a pair had a nest on Cone Butte, but was unable to find it. While at Camp Baker, a bird of this species used to fly over our camp every morning to a coral just beyond, where he would secure a blackbird or two for breakfast, and then return to the mountains.

85. FALCO COMMUNIS ANATUM, (*Gm.*) *Ridgway.*

Duck Hawk.

While ascending the Missouri, we several times saw the nests of this species placed on little ledges on the high washed clay bluffs by which the river is bordered. These nests all contained unfledged young. One or both of the parents was always to be seen sitting near the nest. This species was abundant in the valley of the Yellowstone above Emigrant Peak, and had no doubt bred there, as I took a very young bird.

86. FALCO COLUMBARIUS (?) RICHARDSONI, (*Linn.*) *Ridgway.*

Richardson's Falcon.

A Pigeon Hawk, probably to be referred to this variety, was seen September 5, hovering low over the summit of the Bridger Mountains.

87. FALCO SPARVERIUS, *Linn.*

Sparrow Hawk.

Abundant on the plains and along the Yellowstone River.

88. BUTEO BOREALIS, (*Gm.*) *Vieill.*

Red-tailed Hawk.

Seen on several occasions on the Missouri River.

89. BUTEO BOREALIS CALURUS, (*Gm.*) *Cass.*

Western Red-tailed Hawk.

This was the most common hawk seen in the mountains. We must have seen fifteen or twenty the day that we passed through Bridger's Pass; and they were equally abundant in some parts of the Yellowstone Park.

90. BUTEO SWAINSONI, *Bp.*

Swainson's Hawk.

Rather numerous in the valley of the Yellowstone.

91. ARCHIBUTEO LAGOPUS SANCTI-JOHANNIS, (*Gm.*) *Ridgway.*

Rough-legged Hawk.

Abundant about Gardiner's Springs and in the valley of the Yellowstone.

92. ARCHIBUTEO FERRUGINEUS, (*Licht.*) *Gray*.

Ferruginous Hawk.

This striking species was common on the plains from the Missouri River westward until we reached the mountains. It was often seen sitting on the little mounds raised by the prarie-dogs, gazing intently at the entrance of the burrow, apparently waiting to seize the first one that should appear.

93. PANDION HALIAËTUS, (*Linn.*) *Cuv*.

Fish-hawk.

The Fish-hawk, although occasionally seen on the Missouri, is not, in my experience at least, common on that river below the point where it becomes muddy. Above Carroll, however, the river is quite clear, and there it seems much more numerous. It was nowhere so abundant as on the Yellowstone River; and while traveling along that stream I saw from six to twelve of these birds every day. At the falls of the Yellowstone, this species was constantly in sight, sometimes sailing like a black speck close to the water far below us, or balancing itself on some dead pine that grew half-way up the sides of the cañon.

94. AQUILA CHRYSAËTOS, *Linn*.

Golden Eagle.

Occurs more or less frequently all through the country which we traversed, but is most often seen in the mountains and on high wooded buttes. I saw it at the Forks of the Musselshell, near Bridger Pass, and once over the Missouri River.

95. HALIAËTUS LEUCOCEPHALUS, (*Linn.*) *Sw*.

White-headed Eagle.

Seen several times on the Missouri.

CATHARTIDÆ.

96. CATHARTES AURA, (*Linn.*) *Ill*.

Turkey Buzzard.

Abundant on the plains.

COLUMBIDÆ.

97. ECTOPISTES MIGRATORIA, (*Linn.*) *Sw*.

Passenger Pigeon.

Seen in small companies in July along the Missouri River bottom, where it was doubtless breeding.

98. ZENÆDURA CAROLINENSIS, (*Linn.*) *Bp*.

Common Dove; Turtle Dove.

Common everywhere.

TETRAONIDÆ.

99. TETRAO OBSCURUS, *Say*.

Dusky Grouse; Blue Grouse.

We found this species very abundant from the time that we reached the mountains until we left them again. The first seen were a mother with a brood of small young, taken in the Judith Mountains. From this point to and through the Yellowstone Park they were frequently met with.

There seems to be a wide variation in the time at which these birds deposit their eggs. In the Musselshell Cañon and along Deep Creek I saw many broods of half-grown chicks, and in some cases the young were nearly as large as the parent bird. This was late in July. On the 4th of August, I saw a brood on an extensive prairie in the Little Belt Mountains near Camp Baker, which must have been less than a week old; at all events, they were so young that I had no difficulty in catching several of them alive. Two weeks later I saw a brood on Trail Creek near the Yellowstone River, that were certainly not more than ten days or two weeks old.

The females with their young seem to pass the night in the creek-bottoms, and it is in such places that they must be looked for early in the morning and late in the afternoon. About 9 or 10 o'clock a. m., they proceed on foot to the uplands, where they remain until about two hours before sunset, when they come down to the stream to drink, and remain all night. In returning from the hills, they always fly. The young, when alarmed or uneasy, have a fashion of erecting the feathers of the sides of the neck just below the head, which, when seen at a little distance, gives them a very odd

appearance. The female, when the young birds are nearly approached or captured, makes no attempt to draw away the enemy by any of the artifices employed by *Bonasa umbellus*, but contents herself with wandering anxiously about at a short distance, holding the tail quite erect, and clucking after the manner of the domestic hen under similar circumstances. The young when well grown are delicious eating, and many were killed by us for food when large game could not be obtained. When a brood has been scattered, the individuals which compose it lie well and furnish fair shooting. Though swift fliers, they are easily killed in the open, and I secured most of those that I killed with mustard-seed shot. The birds would sometimes let me approach within three or four feet of them before rising, and they were pretty objects as they crouched waiting for me to take one more step toward them. The body flattened out on the ground, the head and neck straight and pressed against the earth, the tail slightly elevated, and all the while the bright brown eye watching for the slightest sign that the bird's presence was discovered, together made up a picture which, though familiar enough, ever possesses a new interest for me.

But one brood was seen in heavy pine timber. In this case, the family, which consisted of the mother and six or eight well-grown young, took refuge in the lower limbs of a large pine, from which they refused to move until several shots had been fired at them.

Having in mind Dr. Cooper's statement that, in Oregon and Northern California, this species is not seen in winter, I made diligent inquiry among the settlers in the mountains of Montana for information on this point. All of those with whom I spoke informed me that the Blue Grouse was apparently quite as abundant in winter as in summer.

It is to be noticed that I found this species almost invariably in the open creek-bottoms, and sometimes in quite extensive prairies, although always among the mountains. This state of things, which is exactly the reverse of the experience of most other observers, was no doubt due, in part at least, to the fact that the birds had their tender young with them, and that these would be more safe in the valleys than on the mountain-sides.

During the trip, not a single adult male was secured. On the high mountains, however, at and near timber-line, I several times started single birds and small packs of this species. The only one secured in such situations was a barren female; but I think it probable that most of those seen here were old males.

The specimens preserved on the trip seem to be intermediate between varieties *obscurus* and *richardsoni.*

100. CENTROCERCUS UROPHASIANUS, (*Bp.*) *Sw.*

Sage Grouse.

We first saw this species near Wolf Point, on the Missouri, where several were started from the river-bottom by the passage of the steamboat. On Box Elder Creek, where we remained in camp for several days late in July, they were extremely numerous, and broods of young were seen of all ages, from the little chicks that could fly but a few feet to the large strong-winged birds that almost equaled their parents in weight. All were painfully ignorant of the effect of fire-arms, and I have seen a brood of ten or a dozen well-grown birds walk quietly along before two men who were trying to shoot their heads off with rifles, until half their number had been killed. At each report, they would stretch up their necks and gaze around as if a little curious to find out whence the noise proceeded and what it meant, and would then move leisurely on toward the hills, feeding as they went. If, however, a ball touched, but did not fatally wound or cripple a bird, and it rose or fluttered about on the ground, the whole flock took the alarm and were off without delay.

About Box Elder, they seemed to pass the night on the uplands, coming down to the water morning and evening, and retiring to the higher ground before the sun became hot in the morning, and just about sunset in the evening. The young, even when nearly full grown, utter a plaintive, peeping cry, which has the peculiar effect of appearing to come from a long distance off, even though the bird may be quite close at hand.

When seen during the summer, the birds were, of course, in families; but on our return march in September, they had commenced collecting together, and packs of from twenty to fifty individuals were several times seen.

101. PEDIŒCETES PHASIANELLUS COLUMBIANUS, (*Ord.*) *Coues.*

Sharp-tailed Grouse.

I saw this species only on the plains, a state of things which somewhat surprised me; for, although, of course, essentially a prairie bird, I found it during the summer of 1874, in great numbers among the Black Hills of Dakota. They were more numerous on Box Elder Creek than at any other point; and indeed they seem to prefer streams which have a wide bottom overgrown with rose-bushes and other shrubs, on the fruit of

which they feed. The young birds were from one-half to two-thirds grown late in July.

During our passage down the Missouri Rver, we often saw this species on the dry sand-bars that dotted the river, rolling and dusting themselves in the sand. I did not see these birds roosting on trees until September 10, at which time the weather at night was quite cold.

102. BONASA UMBELLUS UMBELLOIDES, (*Linn.*) *Baird.*

Rocky Mountain Ruffed Grouse.

Although this species was said to be extremely abundant in the Yellowstone Park, we saw very few of them, not twenty in all. In habits, they seem to resemble almost exactly the eastern variety. A female, with six or eight young only about a week old, was seen August 19. The young, instead of hiding, flew into the lowest branches of a dead pine, a distance of three or four feet, which they just managed to accomplish, while the female fluttered about at my feet as if in the death agony. I had not the heart to molest the charming little family, and, after watching them for a short time, I moved off, leaving them to their own devices.

CHARADRIIDÆ.

103. ÆGIALITIS VOCIFERUS, (*Linn.*) *Bp.*

Killdeer Plover.

Abundant, breeding on the plains near water.

104. ÆGIALITIS MONTANUS, (*Towns.*) *Baird.*

Mountain Plover.

I did not find this species at all abundant in that portion of Montana which we traversed. Two females, each followed by a newly-hatched young one, were taken near Haymaker's Creek, August 1, and were the only individuals observed during the trip. The mothers displayed much anxiety for their young, and endeavored to lead me away from them by the artifices usual with this family of birds. The young were pretty but rather awkward little objects, and tottered along with uncertain steps, as if their legs were too long and they found difficulty in balancing themselves upon them.

RECURVIROSTRIDÆ.

105. RECURVIROSTRA AMERICANA, *Gm.*

Avocet.

This species abounds on the small alkaline pools that are so common in Dakota, and is quite common in that portion of Montana through which we passed. It was quite numerous on the Yellowstone River above the falls, where the stream is wide, and the wet, grassy banks slope gradually down to the water's edge; and many were seen on the shores of the lake. I also saw a large flock on a small pool near Fort Ellis. They were rather shy, rising in a thick flock at long gunshot, and making the air ring with their shrill cries. A wounded bird unable to fly attempted to escape by diving, making use of the wings for progression under water.

PHALAROPODIDÆ.

106. LOBIPES HYPERBOREUS, (*Linn.*) *Cuv.*

Northern Phalarope.

A flock of thirty or forty of these graceful birds was seen on a small pool near Fort Ellis.

SCOLOPACIDÆ.

107. GALLINAGO WILSONII, (*Temm.*) *Bp.*

Wilson's Snipe.

One individual seen near Fort Ellis.

108. TRINGA MINUTILLA, *Vieill.*

Least Sandpiper.

This species was only observed near Fort Ellis, where, however, it was abundant early in September.

109. TRINGA BAIRDII, *Coues.*

Baird's Sandpiper.

This species was noticed at Fort Ellis, at Gardiner's Springs, and in the Lower Geyser Basin. In the last-mentioned locality, it was seen in flocks of from fifty to sixty individuals.

110. Totanus semipalmatus, (*Gm.*) *Temm.*

Willet.

Abundant on alkaline pools in Dakota and on the Yellowstone Lake.

111. Totanus melanoleucus, (*Gm.*) *Vieill.*

Great Yellowshanks; Telltale.

Abundant on the Yellowstone Lake, and, during September, on the Missouri and streams flowing into it.

112. Totanus flavipes, (*Gm.*) *Vieill.*

Lesser Yellowlegs.

A few birds of this species were seen near Fort Ellis and on the shores of the Yellowstone Lake.

113. Totanus solitarius, (*Wils.*) *Aud.*

Solitary Sandpiper.

This species was observed but twice during the summer; once near Fort Ellis and once in the Upper Geyser Basin.

114. Tringoides macularius, (*Linn.*) *Gray.*

Spotted Sandpiper.

Abundant along the Missouri River, and along mountain-streams as well. On the Missouri, when startled by the approach of the steamboat, they would fly a short distance, and then alight on the slender and pliable twigs projecting from the fresh beaver-houses, on which they would balance themselves with the oddest bobbings and noddings imaginable.

115. Actiturus bartramius, (*Wils.*) *Bp.*

Bartramian Sandpiper; Upland Plover.

Abundant on the plains in Montana. Late in July, I secured young birds nearly as strong on the wing as their parents, and at the same time noticed broods of newly-hatched young.

116. Numenius longirostris, *Wils.*

Long-billed Curlew.

Abundant on the plains. Near Box Elder, and all along the base of the Judith Mountains, large scattering companies of these birds were seen feeding on the prairies. They were quite shy, and could not often be approached within gun-range except by strategy. As we drew near, they would rise, one after another, each uttering his loud, rolling note, until finally all were on the wing. They would then, in a dense flock, for a short time perform a variety of beautiful evolutions high in the air, finally re-alighting at a considerable distance.

ARDEIDÆ.

117. Ardea herodias, *Linn.*

Great Blue Heron.

This species was abundant along the Missouri River in July and September. Prominent objects as they stood on the bare sand-bars, they often drew half a dozen rifle-shots from the steamer as it passed.

GRUIDÆ.

118. Grus canadensis, (*Linn.*) *Temm.*

Sandhill Crane.

Very abundant all through the Yellowstone Park, but not seen on the plains.

RALLIDÆ.

119. Fulica americana, *Gm.*

Coot; Mud-hen.

Abundant in Dakota.

ANATIDÆ.

120. (?) Cygnus buccinator, *Rich.*

Trumpeter Swan.

A single swan seen in flight at the Yellowstone Lake was probably of this species. It was taken on this water by Mr. Merriam in 1872.

121. ANSER HYPERBOREUS, *Pall.*

Snow Goose.

A flock of these birds was seen on the Yellowstone River near the lake; and the species was again observed in considerable numbers on the alkaline pools near the Missouri River in October.

122. BRANTA CANADENSIS, (*Linn.*) *Gray.*

Canada Goose; Common Wild Goose.

The common wild goose was seen in the greatest abundance on the Missouri River, and was numerous on the Yellowstone Lake as well. Early in July, while on the way from Bismarck to Carroll, we saw many broods of young, and, when coming down the river late in September, hardly an hour passed without our seeing one or more large flocks of these birds. The young goslings are pretty little things, and the devotion to them of the mother is interesting. Four was the smallest number seen in a brood, and nine the largest. On one occasion I saw what seemed to be a union of two families. The two females swam in advance side by side, while the ganders brought up the rear, and the nine young ones followed directly behind the females.

When approached while in the water, the birds would gradually sink until nothing but the bill and upper part of the head appeared above the surface; the young would then disappear one after another, and last of all the old female would dive. The male always flew off to a safe distance before the diving commenced; but in no instance did I see the mother leave her brood.

123. ANAS BOSCHAS, *Linn.*

Mallard.

Abundant; breeding along the Missouri and on smaller streams in the mountains.

124. DAFILA ACUTA, (*Linn.*) *Bp.*

Pin-tail Duck.

Observed in considerable numbers on the Yellowstone Lake.

125. CHAULELASMUS STREPERUS, (*Linn.*) *Gray.*

Gadwall; Gray Duck.

Abundant on alkaline pools in Dakota; a female with a brood of newly-hatched young was seen on Box Elder.

126. MARECA AMERICANA, (*Gm.*) *Steph.*

American Widgeon.

Abundant on many of the streams in Dakota and Montana.

127. QUERQUEDULA CAROLINENSIS, (*Gm.*) *Steph.*

Green-winged Teal.

Abundant, breeding on streams in Eastern Montana. On Deep Creek, early in August, I saw many broods of young apparently only a few days old.

128. QUERQUEDULA DISCORS, (*Linn.*) *Steph.*

Blue-winged Teal.

Seen in considerable numbers on the Missouri River in September.

129. SPATULA CLYPEATA, (*Linn.*) *Boie.*

Shoveler.

Quite abundant on alkaline pools in Dakota.

130. FULIGULA AFFINIS, *Eyton.*

Lesser Blackhead.

Abundant on alkaline pools in Dakota.

131. BUCEPHALA ALBEOLA, (*Linn.*) *Bd.*

Dipper; Buffle-head.

This species was rather common on the little mountain lakes and streams of Montana. On one of the forks of Deep Creek, a female, with half a dozen young not yet able to fly, was seen, and several of the young secured. Afterward families of this species were quite frequently observed.

132. (?) Œdemia fusca, (*Linn.*) *Flem.*

White-winged Surf Duck.

Seen on the Yellowstone Lake in August. I mention this species with a query, because, although I recognized it satisfactorily to myself, I took no specimens. The locality is quite out of the range usually ascribed to this bird.

133. Mergus merganser, *Linn.*

Goosander.

Observed in considerable numbers on the Yellowstone Lake. In August, the young were not yet able to fly.

134. Mergus cucullatus, *Linn.*

Hooded Merganser.

Rather common along the Missouri River.

PELECANIDÆ.

135. Pelecanus trachyrhynchus, *Lath.*

White Pelican.

Very abundant on the Yellowstone Lake, but shy and difficult of approach.

LARIDÆ.

136. Larus delawarensis, *Ord.*

Ring-billed Gull.

Common on Yellowstone Lake and on the Missouri River.

COLYMBIDÆ.

137. Colymbus torquatus, *Brunn.*

Loon ; Great Northern Diver.

Observed frequently on alkaline pools in Dakota and on the Missouri River.

PODICIPIDÆ.

138. Podiceps cornutus, *Lath.*

Horned Grebe.

Abundant during migrations on the Missouri, and all streams and pools in the mountains.

139. Podilymbus podiceps, (*Linn.*) *Lawr.*

Pied-billed Grebe.

Abundant on alkaline pools in Dakota.

PARTIAL LIST OF THE MAMMALS AND BIRDS OF THE YELLOWSTONE PARK.

This list, which is of course very incomplete, consists merely of the observations of Mr. C. H. Merriam in 1872, and those made by myself in 1875. Such species as were noticed by only one observer are followed by the initial letter of his name.

MAMMALS.

1. *Nycticejus crepuscularis*, Allen, M.
2. *Vespertilio lucifugus*, LeConte, M.
3. *Vespertilio yumanensis*, Allen, M.
4. *Felis concolor*, Linn, G.
5. *Lynx rufus*, Raf., G.
6. *Lynx canadensis*, Raf., G.
7. *Canis occidentalis*, Rich., G.
8. *Canis latrans*, Say, G.
9. *Mustela americana*, Turton, G.
10. *Putorius pusillus*. Aud. & Bach., M.
11. *Gulo luscus*, Sabine.
12. *Mephitis mephitica*, Baird, M.

13. *Mephitis bicolor*, Gray, M.
14. *Ursus horribilis*, Ord.
15. *Ursus americanus*, Pallas.
16. *Sciurus hudsonius*, Pallas.
17. *Tamias quadrivittatus*, Say.
18. *Spermophilus townsendi*, Bach., M.
19. *Arctomys flaviventer*, Bach.
20. *Castor canadensis*, Kuhl.
21. *Thomomys talpoides*, Rich.
22. *Zapus hudsonius*, Coues.
23. *Hesperomys leucopus sonoriensis*, LeConte.
24. *Arvicola riparia*, Ord.
25. *Erithizon epixanthus*, Brandt.
26. *Lepus bairdii*, Hayden, M.
27. *Lagomys princeps*, Rich., M.
28. *Alce americanus*, Jardine.
29. *Cervus canadensis*, Erxleben, G.
30. *Cervus macrotis*, Say, G.
31. *Antilocapra americana*, Ord., M.
32. *Ovis montana*, Cuv., G.
33. *Bos americanus*, Gmelin, G.

BIRDS.

1. *Turdus migratorius*, Linn.
2. *Oreoscoptes montanus*, (Towns. (Baird.
3. *Mimus carolinensis*, (Linn.) Gray.
4. *Cinclus mexicanus*, Sw.
5. *Sialia arctica*, Sw.
6. *Regulus calendula*, (Linn.) Licht., M.
7. *Parus atricapillus septentrionalis*, (Harris) Allen, G.
8. *Parus montanus*, Gambel, M.
9. *Sitta carolinensis aculeata*, (Cass.) Allen.
10. *Troglodytes aëdon parkmanni*, (Aud.) Coues, M.
11. *Cistothorus palustris*, (Wils.) Baird, G.
12. *Anthus ludovicianus*, (Gm.) Licht., M.
13. *Dendrœca audubonii*, (Towns.) Baird.
14. *Geothlypis philadelphia macgillivrayi*, (Wils.) Allen G.
15. *Myiodioctes pusillus*, (Wils.) Bp., M.
16. *Pyranga ludoviciana*, (Wils.) Bp.
17. *Hirundo horreorum*, Barton.
18. *Hirundo thalassina*, Sw.
19. *Petrochelidon lunifrons*, (Say) Scl.
20. *Carpodacus cassini*, Baird
21. *Loxia curvirostra americana*, (Wils.) Coues, G.
22. *Chrysomitris pinus*, (Wils.) Bp.
23. *Poœcætes gramineus confinis*, (Gm.) Bd.
24. *Melospiza melodia fallax*, (Wils.) Ridgway.
25. *Junco oregonus*, (Towns.) Baird.
26. *Spizella socialis arizonæ*, (Wils.) Coues.
27. *Zonotrichia leucophrys*, Sw.
28. *Zonotrichia leucophrys intermedia*, Ridgway, M.
29. *Chondestes grammaca*, (Say) Bp., M.
30. *Goniaphœa melanocephala*, (Sw.) Gray, M.
31. *Cyanospiza amœna*, (Say) Baird, M.
32. *Pipilo chlorurus*, (Towns.) Baird, M.
33. *Molothrus pecoris*, (Gm.) Sw., G.
34. *Icterus bullockii*, (Sw.) Bp., M.
35. *Picicorvus columbianus*, (Wils.) Bp., G.
36. *Pica melanoleuca hudsonica*, (Sab.) Coues.
37. *Cyanurus stelleri macrolophus*, (Baird) Allen.
38. *Perisoreus canadensis capitalis*, Baird.
39. *Tyrannus verticalis*, Say, M.
40. *Contopus borealis*, Baird, M.
41. *Contopus virens richardsonii*, (Sw.) Allen.
42. *Empidonax pussillus*, Cab., M.
43. *Ceryle alcyon*, (Linn.) Boie, G.
44. *Picus villosus harrisii*, (Linn.) Allen, M.
45. *Picus pubescens*, Linn., G.
46. *Picoides arcticus*, (Sw.) Gray, M.

47. *Picoides americanus dorsalis*, (Brehm) Baird, M.
48. *Sphyrapicus thyroideus*, (*Cass.*) Baird.
49. *Melanerpes erythrocephalus*, (Linn.) Sw., G.
50. *Melanerpes torquatus*, (Wils.) Bp.
51. *Colaptes mexicanus*, Sw.
52. *Otus vulgaris wilsonianus*, (Less.) Allen, M.
53. *Surnia ulula hudsonia*, (Gm.) Coues, M.
54. *Circus cyaneus hudsonius*, (Linn.) Schl.
55. *Nisus fuscus*, (Gm.) Kaup.
56. *Falco communis anatum*, (Gm.) Ridgway, G.
57. *Falco sparverius*, Linn.
58. *Buteo borealis calurus*, (Gm.) Ridgway.
59. *Buteo swainsoni*, Bp.
60. *Archibuteo lagopus sancti-johannis*, (Gm.) Ridgway, G.
61. *Pandion haliaëtus*, (Linn.) Cuv.
62. *Tetrao obscurus*, Say.
63. *Bonasa umbellus umbelloides*, (Linn.) Baird.
64. *Ægialitis vociferus*, (Linn.) Bp.
65. *Recurvirostra americana*, Gm., G.
66. *Tringa bairdii*, Coues.
67. *Totanus semipalmatus*, (Gm.)Temm., G.
68. *Totanus melanoleucus*, (Gm.) Vieill.
69. *Totanus flavipes*, (Gm.) Vieill., G.
70. *Totanus solitarius*, (Wils.) Aud., G.
71. *Grus canadensis*, (Linn.) Temm., G,
72. *Cygnus buccinator*, Rich.
73. *Anser hyperboreus*, Pallas, G.
74. *Branta canadensis*, (Linn.) Gray, G.
75. *Dafila acuta*, Jenyns, G.
76. *Bucephala albeola*, (Linn. Baird, G
77. (?) *Œdemia fusca*, (Linn.) Flem., G
78. *Mergus merganser*, Linn., G.
79. *Pelecanus trachyrhynchus*, Lath., G.
80. *Larus delawarensis*, Ord, G.
81. *Podiceps cornutus*, Lath., G.

GEOLOGICAL REPORT, BY EDWARD S. DANA AND GEO. BIRD GRINNELL

YALE COLLEGE, NEW HAVEN, CONN., *June* 1, 1876.

SIR: We have the honor to hand you herewith a report on the geology of a "Reconnaissance from Carroll, Montana, to the Yellowstone Park, and return," made under your command during the months of July, August, and September, 1875.

In submitting the narrative of our examination of the country passed over, we wish to express to you our grateful appreciation of your uniform kindness and constant willingness to facilitate our investigations by every means in your power. To Lieut. C. F. Roe, who commanded our escort from Carroll to Camp Baker, we are under obligations for many kindnesses. At Camp Baker, Fort Ellis, and Camp Lewis, we were the recipients of most generous hospitalities from the officers of those posts; and our brief delays at those points are remembered by us as being among the pleasantest days of the trip.

The vertebrate fossils collected during the summer were submitted to Prof. O. C. Marsh, and by him identified. The invertebrates were examined by Mr. R. P. Whitfield, of Albany, and his identifications, with occasional comments on the specimens, will be found in the body of the report. A paper by Mr. Whitfield, describing such new forms as were discovered during the summer, accompanies our report. To both of these gentlemen our thanks are due for the many favors that we have received from them.

We remain, sir, very respectfully, your obedient servants,

EDWARD S. DANA.
GEO. BIRD GRINNELL.

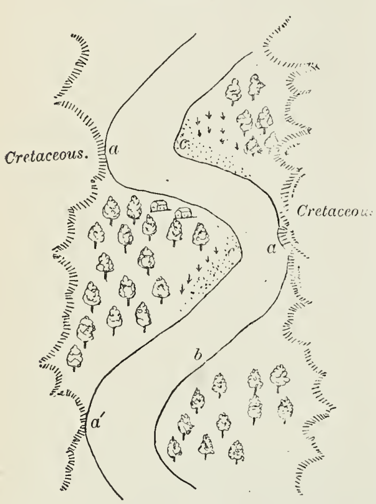
Col. WM. LUDLOW,
Chief Engineer of the Department of Dakota, Saint Paul, Minn.

PRELIMINARY REMARKS ON THE ALLUVIAL DEPOSITS OF THE UPPER MISSOURI RIVER.

The town of Carroll is situated in the alluvial bottom of the Missouri, which is at this point quite extensive, and well timbered with a fine growth of cottonwood. The course of the river-valley is here easterly, and it continues for a considerable distance with but little change in general direction, though the valley varies very considerably in width between the high walls of Cretaceous clays which rise on either side of it. The river sometimes winds along through a bottom 2 or 3 miles wide, and again is confined to a narrow passage between the steep, washed bluffs several hundred feet in height.

The alluvial phenomena are those which are always observed under similar circumstances, though they take place here more rapidly and on a larger scale than is often the case, in consequence of the vast amount of solid matter which the river is constantly carrying down. On this account, the "muddy Missouri" offers peculiar advantages for the study of alluvial changes; and, could a series of observations be carried on at a few points during two or three seasons, a large amount of data might be collected which would lead to interesting and valuable conclusions. At Carroll, we have an example of a condition of things which may be observed at almost any point in this part of the river, and a few words of explanation may consequently not be out of place.

Fig. 1.



At *a*, on the outer bank of the river, the current is strong, and has forced itself close up under the high bluffs, whose top forms the border of the broad prairie above. The older deposits, at points such as this, are directly acted upon by the running water, and are thus gradually undermined and worn away, the material being carried on by the current. Upon the opposite side of the stream, at *c*, the current is weaker, the water shallow and eddying, and the shore runs out to meet the water in a long, low sand-bar. At *b*, there is a high bank of alluvial clays, 10 feet or more above the stream, deposited long before in time of flood, but now being rapidly torn away. Still again at *a′* the water washes at the foot of the older bluffs, while opposite is the never-failing sand-point.

Thus the river winds on its course, touching the hills, which form the true limit of its valley, only here and there. For the greater part of its course, it is confined between the alluvial banks. It is safe to say that, except in the spring, the river deposits comparatively little solid matter, and this chiefly on the sand-spits and bars, where the force of the moving water is small. The work of the river is at this season one of destruction more than deposition, tearing down what it has itself previously built up, and also to a less extent carrying away the older deposits. It acts alone, unaided by any minor tributary streams; for they are dry except in the early season. Even during the summer, however, the channel is constantly changing. The mud and sand bars which are everywhere formed do not long retain their positions, but are moved on down the river and heaped up again in other places. Thus the process is one of gradual transferral down the stream; the solid matter going to make one alluvial bank after another, until it is finally deposited in the Gulf of Mexico.

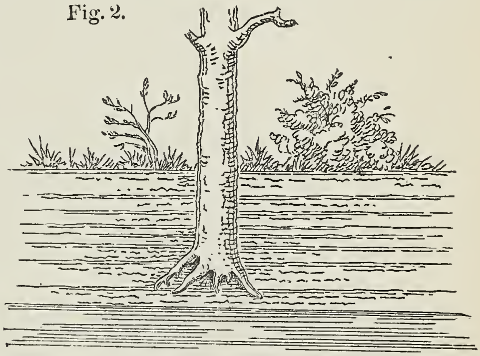
It is interesting to note, in this connection, the explanation recently given by Prof. James Thomson (Proc. Royal Society, 1876) of the origin of the windings of rivers in alluvial plains. He shows that, upon hydraulic principles, the velocity of the stream must be greater on the inner bank than on the outer, and yet, as shown here, the wearing away takes place upon the outer bank, and the deposits are made on the inner bank. This is in part due to the centrifugal force, which tends to make the surface-water move away from the inner bank, while its place is taken by a partial upward current of the bottom water retarded much by friction. This current moves obliquely toward the inner bank, and serves to protect it from the rapid scour of the stream-line. On the outer bank, however, there is a tendency of the rapidly-moving surface-water, unimpeded by friction, downward against the solid bank; this it tends to wear away, the worn substance is carried down to the bottom, where the oblique current spoken of carries it toward the inner bank. Sooner or later it will reach this point, and more or less of it will find a resting-place.

These principles find an application in the flow of the Missouri through its alluvial plain. It is on the outer bank of the successive curves of the river that the wear is greatest and that the river has forced its way up to the older bluffs, while on the inner

bank the deposits are being made, more or less, all the time, sand or mud or both, according to the relative velocities of the different parts of the stream.

As has been remarked, the work of the river in summer is destructive, and no additions are made at this time to the height of the alluvial banks. In spring the case is very different, and it is at that time that the chief deposits of alluvium are made. The river is then full, the snows all over the wide area drained by the Missouri are melting, rains are frequent, and a vast amount of material is brought in from the surrounding country. The amount of solid matter held in suspension at this season is enormous. In floods the waters rise many feet, overspreading the lower alluvial ground, and in subsiding and evaporating they deposit their load of sand and clay, sometimes covering a well-grown and fertile plain with a bed of alluvium a foot and more in thickness. This sometimes takes place for a number of successive years at the same points, as is shown by the fact that the roots of trees which must have been close to the surface of the ground when they commenced to grow were often seen buried beneath from 4 to 6 feet of alluvium. We could of course only observe this on the very edge of the bank, where the water had removed a part of the old alluvium, exposing to view the roots, and that part of the trunk which had been buried. Some of these trees were quite small, not more than 3 or 4 inches in diameter, and most of them were still living; thus indicating how rapidly such deposits as those referred to are made. The trees were mostly cottonwoods and elms, species of rapid growth. That these deposits are made very rapidly is also shown by the thick layers to be noticed in any section of a bank so deposited, sometimes a foot or more, perfectly homogeneous. It is interesting to note the great variation in the height of the perpendicular alluvial banks. From point to point, in some cases, it is only 3 or 4 feet; in others, 25 feet or more. This depends obviously on the strength of the current and the extent to which the water is backed up. It bears upon the general subject of river-terraces. Not infrequently we observed a second terrace above, or rather a long line of high cut bluffs separated from the stream by another alluvial plain. (See Fig. 3.) This is all of recent origin, and merely means that the river stopped washing away the bluffs here and commenced to fill up at its foot.

Fig. 2.



The energy of the stream is at all times directly proportional to the amount of the descending water, and hence is immensely greater in spring than in summer. This energy is probably all expended in overcoming friction and in carrying the load of solid matter. The difference in the amount of detritus held in suspension by the stream in early July and in late September was very marked; at the latter time the stream seemed to have to a great extent cleared itself. This is doubtless due to the diminished volume of the water, in consequence of which the carrying power of the stream was so much diminished. A river of this character seems to act as a destructive agent rather through the weight and moving force of its own water than by means of the abrading power of the solid matter it carries with it.

A true upper terrace was not observed at any point above the mouth of the Yellowstone. At points below, it was not uncommon to see one hugging the lignite bluffs, and separated from the river by a wide alluvial plain. Whether it be a true terrace or only a recent deposit is doubtful. Such a place was noticed a short distance below Fort Buford, where the water must once have spread over an immense area, pointing to the time when the Missouri was a much larger stream than it is at present.

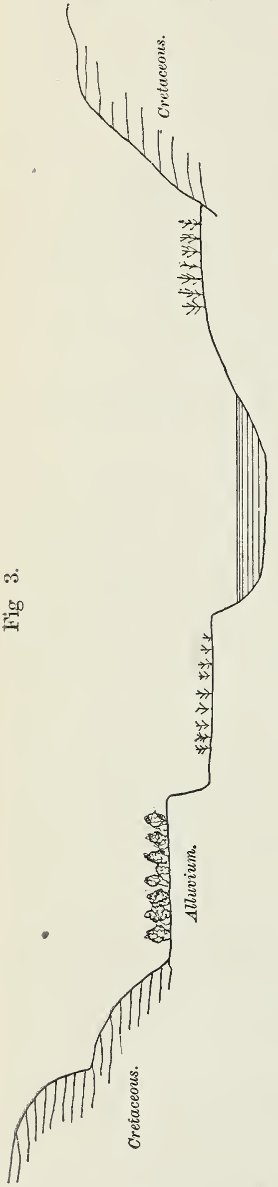
Above Carroll, the river-bottom becomes much less wide, and, although sometimes flowing through valleys more or less broad, the stream generally passes along between and close beneath frowning banks of washed clays and sands. The undermining of the banks takes place here in the same manner as where they are alluvial; but, owing to the greater hardness and thickness of the older rocks upon which the water acts, the process is much more slow. It goes on constantly, however, so that at last a great mass of the rock above, perhaps a hundred feet in thickness, deprived of its support, slips down into the water. This has occurred at many points, and gives to the rocks, as viewed from the river, a great variety of dip, which has been considered by some observers as indicating an extensive disturbance of these beds, due to the elevation of the mountain-ranges of this section of the country. We cannot doubt, however, that all these apparent disturbances are purely local, and have been caused by the action of running water.

FROM CARROLL TO BOX ELDER CREEK.

Fort Pierre Group of the Cretaceous.

The clay bluffs at Carroll rise abruptly above the alluvial bottom on both sides of the river. They belong to what Dr. Hayden has called the Fort Pierre Group, Cretaceous No. 4. These bluffs consist of a dark blue to purplish-black laminated clay, occasionally stained with iron, and sometimes containing very thin layers of white sand. They are remarkably constant in character from top to bottom. Dr. Hayden has stated in general that the clays of No. 4 are *not* laminated; but this is not true of those which came under our observation.

Fig. 3.



The characteristic features of this clay are (1) the large calcareous concretions, which will be spoken of more particularly in connection with Crooked Creek; (2) the plates and crystals of transparent gypsum, or selenite; and (3) the alkaline deposits.

The selenite plates are quite conspicuous as they lie on the surface of the ground and glisten brilliantly as the sun strikes them. In general, they are irregular crystalline fragments; but occasionally perfect crystals are found of the form common in the clay of Poland, Ohio. The surface of all these fragments is roughened and etched by the solvent action of the water which has flowed over them. These etchings are most distinct on the clinopinacoid, and are similar to those described by Baumhauer as having been produced artificially by the action of caustic potash. The selenite plates are found most abundantly near the level of the river, having been washed together here; but they occur also more or less frequently on the plains, twenty-five miles from the river, at a level nearly 1,000 feet above.

The alkaline deposits seem to be particularly abundant in some layers, exuding from the bluffs along the river in long white lines. Considerable deposits of it are seen at various points on the banks of the river, and all the little dry creek-bottoms leading into the Missouri are white, as if frosted with it. The following is an analysis of a particularly pure specimen of the alkali collected near Carroll. For this analysis we are indebted to Mr. Fred. P. Dewey, of the Sheffield Scientific School of New Haven, and we would here express our acknowledgments to him:

	I.	II.	Mean.
MgO	11.69	11.91	11.80
Na_2O	15.81	16.20	16.00
CaO	0.53	0.68	0.60
Li_2O	0.88	0.88	0.88
SO_3	44.09	44.12	44.10
Cl	trace	trace	trace
H_2O	23.09	23.00	23.05
Insoluble	3.29	3.27	3.28
	99.38	100.06	99.71

As will be seen from this analysis, the alkali consists essentially of the sulphates of sodium and magnesium; in fact, the amount of sulphuric acid given is almost exactly what is required to unite with the several bases. The presence of the lithia is also to be noticed.

This alkali is a constant attendant of this member of the Cretaceous, wherever observed in the West, and is one of the causes of its barren character. The water of the Missouri is so entirely derived from pure mountain-sources—even the large rivers, as the Musselshell, which flow through the alkaline prairie, being nearly dry at their outlets—that it is little affected by the salt which is brought into it, though the white deposits on the alluvial banks show that the quantity is not small.

These Cretaceous clays have a laminated shaly structure wherever exposed; they weather down so readily, however, that often only the rounded beds of clay are seen. These are so soft and yielding that the foot sinks deeply into them, and they have

much the feeling of a bed of ashes. In the neighborhood of Carroll there is more or less of a scanty vegetation; but farther down the river, perhaps 150 miles, there seems to be no vegetation whatever, and the appearance of these black clay-beds is desolate in the extreme.

The height of the Cretaceous bluffs above the river is quite variable as viewed from the water; but, when we examine the total elevation attained in passing back from the river, we find that it is remarkably constant. The Helena road at Carroll rises in two or three very steep pitches the greater part of its final ascent, and, within 2 or 3 miles of where the road leaves the valley, the high plateau is reached, which is kept, with little change of level, beyond Crooked Creek. The height here, as given by an aneroid, is 665 feet. On the other side of the river the height of the corresponding plateau is 680 feet; though in this case the final elevation was found a little farther from the river, the rise of the plain being more gradual after the first steep ascent had been made.

The appearance of the surrounding country, as viewed from the top of the bluffs back of Carroll, is very forbidding. The whole landscape is of a somber gray tint; the color of the soil and the sage-brush sparingly relieved by the dark green of the stunted pines that grow here and there on the summits of the bluffs and along the little ravines. There is little vegetation, except the *Artemisia*, and, altogether, the region seems incapable of affording sustenance to man or beast. Notwithstanding its uninviting appearance, the neighboring country abounds in game. This region has been, and still is, though to a less extent than formerly, the favorite feeding-ground of a portion of the great northern herd of buffaloes: antelope are numerous on the plains, and mule-deer and elk are found in the pine-timbered ravines. Farther back from the river, in the hill country, the big-horn, or mountain-sheep, and the grizzly bear occur, though nowhere numerous.

On both sides of the Missouri, the high bluffs are cut into numberless ravines, which divide and subdivide again to a wonderful extent, thus carrying the surface-drainage back into the river. These ravines are often quite well wooded, and some of them contain a little strongly alkaline water.

As has been remarked, the height of the plateau varies but little as we proceed away from the river, though we soon pass over the divide which separates the immediate drainage of the Missouri from that of Crooked Creek, tributary of the Musselshell River.

Little Crooked Creek, 13 miles from Carroll, retains water in holes until midsummer, when it generally dries up entirely. Five miles beyond, a branch of Crooked Creek also affords a little poor water in the early summer; but, late in the season, the only water on the route is found in pools in the bed of Crooked Creek, and this is decidedly unpalatable. All these creeks, with their many dry branches, certainly contain swiftly-running water in the early season, when the spring rains unite with the melting snows to swell the streams. This is plainly shown by the high, cut banks and the large accumulations of drift pebbles in the turns in the creek-beds.

The surface of the prairie from Carroll to Crooked Creek (twenty-one miles) and beyond, though this point is only about 15 miles from the river in a direct line, is scattered with drift deposits. These are of two kinds: (1) large, mostly angular, blocks of syenite and other hornblendic rocks, with occasionally some semi-crystalline limestone; and (2) small, smoothly rounded pebbles, consisting to 90 per cent. of a brown quartzite or jasper. Some fragments of fossil wood may here and there be found, and a large variety of pebbles or various kinds of rocks in small quantities. This drift is entirely *superficial*, no proper deposits having been observed at any point. The lithological character of the drift will be described more in detail hereafter, when it will be connected with observations made north of the Missouri River, (p. 135.)

At Carroll, in the lower levels of the Cretaceous No. 4, the only fossils observed were *Baculites ovatus*, Say, and a large *Inoceramus*. At Little Crooked Creek, where we made our first camp, (July 13,) we had more opportunity for search, and here, and farther on, at Crooked Creek, we found:

1. *Lucina ventricosa*, M. & H.
2. *Lucina occidentalis*, Morton.
3. *Mactra*, sp.?
4. *Inoceramus tenuilineatus*, H. & M.
5. *Anchura*, sp. (specific features not shown.)
6. *Ammonites Halli*, M. & H.
7. *Scaphites nodosus*, Owen.
8. *Baculites ovatus*, Say.

Inoceramus tenuilineatus, H. & M., *Ammonites Halli*, M. & H., and *Baculites ovatus*, Say, were extremely abundant at these localities, and the specimens secured comprised individuals of all ages.

These fossils, as far as our observations go, are found only in the concretions previviously mentioned in connection with these beds. These concretions occur in great

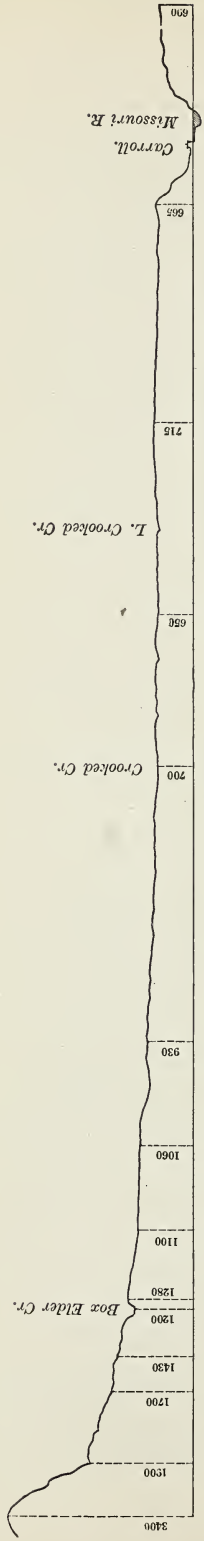


Fig. 4.

Profile Section from Carroll to Cone Butte, Judith Mountains. Course from Carroll to Box Elder Creek S. 55° W.; from Box Elder Creek to Cone Butte S. 30° W. Distance direct about 40 miles.

numbers from the level of the river to the highest point above it where these clays were seen. Those which contain fossils seem to be much more abundant in the upper layers than in those nearer the water's level. Fossils were occasionally found in concretions from the lower ravines; but such concretions were not seen in place. They were generally found imbedded in the loose, washed clays of the ravine, and had the appearance of having been carried down from some point above. The concretions are quite compact when found in place in the cut bank, though they yield readily to a blow of the hammer. Whenever exposed for any length of time, however, to atmospheric influences, they separate into hundreds of angular fragments; and here and there over the prairie may be seen the little piles of these blocks, a conspicuous feature among the low cactus-plants.

The concretions are generally a foot or two in diameter, though sometimes much larger, and are extensively cracked; the seams having been filled with crystallized calcite and sometimes with gypsum. One fine specimen of an *Ammonite* was found, the interior of which was lined with exceedingly delicate crystals of the selenite. The concretions, as a rule, are not distributed at random through the clays, but lie in layers, sometimes closely contiguous, so as to form an almost uninterrupted stratum. The large majority are destitute of fossil remains; but occasionally they are met wi h, containing large numbers of the shells, a considerable number forming the nucleus of a single concretion. It is to be noticed that these fossils, as a rule, are not clustered together in the center of the concretion, but lie in a single layer; and it is not uncommon to see this layer continued in line from one concretion to the others lying immediately adjoining it. This fact indicates the relation in point of time between the deposit of the shells and the formation of the concretions.

The most common fossil in this association, and one which is met with almost everywhere on the prairie, is the *Baculites ovatus*, Say. These remains are often called "fossil fish," fossil ferns," &c., by the white inhabitants of that section of the Territory; and, as they are so well known and so often spoken of, it may not be amiss to make a remark in regard to them for the benefit of the unscientific. They are not fish-skeletons, but are simply the shell of an animal somewhat allied to the present *Nautilus*, but having the shell straight and tapering instead of curved in a spiral. The delicate lines on the shell show the divisional walls, or septa, of the successive chambers in the shell.

During a delay of a day at Crooked Creek, we were enabled to follow along the dry bed of the stream for several miles. This bed is filled with alluvial deposits of the black clay deposited by the stream, and through which it has again washed out its path, leaving steep walls 3 feet or more in height. The banks on either side show evidence of having been washed over, looking white and a little sandy, and with the drift-pebbles collected in large numbers. Here and there the Cretaceous clays are exposed in high bluffs on either side of the creek-valley. These bluffs have sometimes a height of 50 to 75 feet above the stream-bed. The clays are not to be distinguished from those forming the immediate banks of the Missouri. They are blue-black or slate-colored, shaly, the layers being very distinct and everywhere characterized

by the concretions. The layers of the clay are pretty uniformly horizontal, though an occasional slight dip is to be observed. At one point, we noticed a very low synclinal fold followed by a fault; the strata being displaced some 15 or 20 feet. This and other similar disturbances observed in this neighborhood we decided were undoubtedly local, being due to slips in the loosely-laminated clays, through the influence of running waters. Many similar disturbances were observed along the river which were obviously due to a similar cause, (see p. 683.)

From Crooked Creek, the road runs on nearly southwest, rising slightly till a point some few miles from Box Elder Creek is reached, when there is a more sudden rise of 50 feet up to a plateau, which on top is very level, and the northern edge of which can be distinctly seen extending some distance in both directions.

The foregoing cut (Fig. 4) gives an ideal section* from Cone Butte to the Missouri along the line of the road, as obtained from measurements made by an aneroid. It is to be observed that the line runs obliquely, making the distance somewhat farther than in a direct line, as will be seen by reference to the map.

The highest point at which the undisturbed Fort Pierre Group was observed was 1,060 feet above the river; and deposits of this age were seen at various points along the Helena road until Camp Lewis was reached. The last point at which they were noticed was near the crossing of Warm Spring Creek, south of the Moccasin Mountain

The rise of the land continues until we reach Box Elder Valley, where the high plateau is seen extending east and west, and here a descent of 80 feet is made to the level of the stream.

Box Elder Creek takes its rise in the Judith Mountains, and, after a northerly course of about 7 miles, turns easterly and then southeasterly, finally reaching the Musselshell River. At the stage-station, where we camped for several days, its course is nearly east and west. It is a running stream and furnishes fair water. Our delay at this point gave us an opportunity to explore to some extent the Judith Mountains.

In the neighborhood of Box Elder, we pass from the Fort Pierre clays, Cretaceous No. 4 of Hayden, to the sandstones of the Fox Hills Group, or Cretaceous No. 5, overlying them. At a locality lying nearly south of Box Elder station and distant from it about a mile, we observed a ledge of sandstone containing some tolerably-preserved shells. The rock is a yellow ferruginous sandstone in rather thin beds, but quite firm. Occasional calcareous layers contain fossils similar to those in the sandstone, but much better preserved. The thickness of this yellow fossil-bearing sandstone is small; and beneath it is a friable white sandstone, easily rubbed into powder with the fingers. The dip of the exposed strata is slight, toward the northeast. The fossils found at this locality are as follows:

1. *Sanguinolaria oblata*, Whitf., (n. sp.)
2. *Liopistha* (*Cymella*) *undulata*, M. & H.
3. *Tellina isomma*, Meek.
4. *Tellina scitula*, M. & H.
5. *Mactra warreniana*, M. & H.
6. *Mactra maia*, Whitf., (n. sp.)
7. *Tapes montanensis*, Whitf., (n. sp.)
8. *Ostrea congesta*, Con.???
9. *Lunatia concinna*, H. & M.
10. *Inoceramus*, sp.
11. *Fusus Galpinianus*, M. & H.

Sandstones of a similar character to that mentioned may be seen at a variety of points where the excavation of the deep coulées has laid bare the rock beneath. One striking locality was visited some 4 miles east of the station, where, on the east bank of a deeply-cut coulée, the sandstone is exposed at a height of 200 feet above the creek-bottom.

The section was as follows:

Two feet of a white sandstone, in thin layers;

Thirty feet of a white, soft, thickly-laminated sandstone, underlaid by an uncertain thickness of rusty-yellow sand-rock.

No fossils were found here, though they were searched for with care.

JUDITH MOUNTAINS.

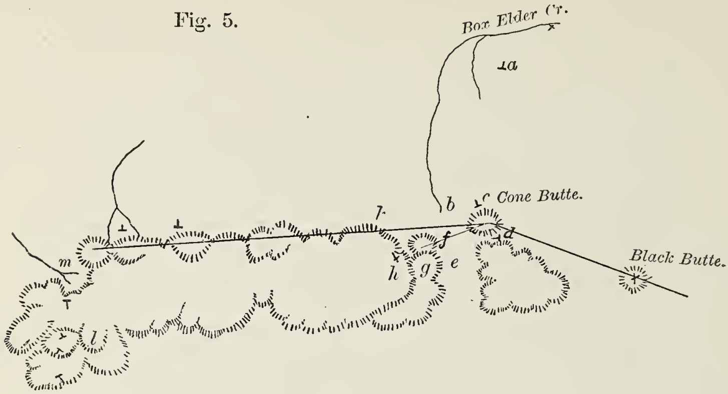
Our examination of the Judith Mountains was hasty and incomplete, owing to lack of time at this point; and our movements were still further embarrassed by the necessity of taking some precautions against the hostile Sioux, known to be in the vicinity at the time.

The following cut (fig. 5) will give some idea of the extent and bearings of the Judith

* The vertical distances are increased nine times to admit of being brought within the limits of the page. The horizontal scale is (as on the map) 6 miles to the inch; the vertical scale is ⅔ mile (3,520 feet) to the inch.

Mountains, although it makes no pretensions to topographical accuracy. The few bearings which were taken from Cone Butte are indicated. It is to be noticed that

Fig. 5.



these mountains do not lie north and south on the east bank of the Judith River, where they are generally represented on the maps of this region. On the contrary, their trend is essentially east and west, so that the axis of the range lies almost at right angles with the course of the river. The general appearance of the range as viewed from a point to the northeast is shown in figure 6.

In the neighborhood of Box Elder, we pass, as has been stated, from the Fort Pierre clays to the sandstones of the Fox Hills Group overlying them. The rocks of this group extend widely east and west from this point, and from the hills which slope up to the foot of the Judith Mountains.

Near Box Elder station, the sandstone shows itself nearly on the level of the stream at a point hardly a mile distant from it to the south. This is the locality where the fossils above mentioned were found. From this point, in approaching the hills, we took a course nearly south up a coulée, then dry, but which had been deeply excavated by running water, and which in the spring is no doubt a considerable tributary of Box Elder Creek. The eastern bank of this coulée is quite high above the bed, perhaps 200 feet, and all the way has a very uniform slope up to the mountains. On the west side the terrace is quite low, but has also the same gradual slope upward; the surface being for the most part remarkably level. The slope is about 50 feet to the mile. The sandstone of No. 5 is seen at a number of points, both in the bed of the coulée and above in the high eastern bank just referred to. The slope upward on the east continues until within a mile or so of Cone Butte, where the sandstone strata are more upturned and the surface of the hill is more broken. Close to the Cone Butte, at its foot, (at *c*, fig. 5,) we observed the sandstone, elevated 750 to 800 feet above Box Elder. It was here whitish, compact, weathering out into peculiar forms, with irregular layers of ferruginous sand; dip, 10°; strike, north 80° west.

The thickness here, as elsewhere, is difficult to estimate, because of the insufficient exposure. It must be two or three hundred feet, or perhaps more. It may be mentioned here that the hills and terraces are so much covered with grass and soil that exposures of rock are rare. Below this point (at *b*, see map) is an exposure of blue laminated clays, with abundant concretions, probably the Fort Pierre Group again, though here 600 feet above the highest exposure observed below, and 400 feet above the sandstone identified as No. 5, (*a*, on map.) The elevation is due to the upturning of the mountains, involving both members of the Cretaceous alike.

From here we made the ascent of Cone Butte. The immediate foot-hills, and indeed those at some distance from the peak, are made up of the talus from the mountain as far as the surface-exposure goes. Loose blocks of the trachyte, which forms the mass of the mountain, have been spread over the surrounding country to a remarkable extent, and the smaller fragments were found abundantly within a mile or two of Crooked Creek; that is, having crossed Box Elder Valley. Cone Butte is, as has been intimated, a trachytic hill, and according to the readings of our aneroid it is 2,200 feet above Box Elder, and 3,400 above the Missouri River. This is about the average height of what are called the Judith Mountains, though there are several points which are probably a little higher.

The summit of Cone Butte commands an extensive view over the prairies of the north. The Little Rocky Mountains and the Bear's Paw Mountains, though far in the distance, are the most conspicuous points to be noticed. Its commanding position is well appreciated by the Indians, who use it as a lookout, for which it is most conveniently

situated. A shelter which we found on the summit, formed of large flat blocks of trachyte resting upon the spreading branches of a stunted pine-tree, had doubtless been used as a resting-place by many an Indian scout.

Cone Butte is itself a conspicuous object from all the surrounding country, even as far north as the Little Rocky Mountains; its perfectly conical shape being very striking from any point on the Carroll road. Viewed from the west, the sides of the cone are broken, and not so symmetrical as shown in figure 6. The slopes are covered with loose blocks of trachyte, and at some points are precipitous. The angle of the cone is about 40° or 41°; indeed, it is so steep, and the loose blocks of trachyte furnish so insecure a foot-hold, that, were it not for the trails made by the mountain-sheep ascending and descending, it would be no easy task to climb it from the west side.

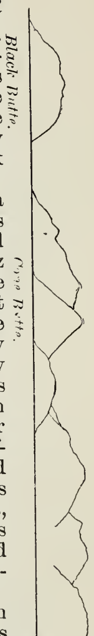


Fig. 6.

The mineralogical character of this trachyte deserves to be described a little in detail, as it may be taken as a type of the variety which occurs most widely in these mountains. It is in general of uniform texture, hard and firm, though occasionally showing minute cavities containing quartz crystals as a secondary product. It breaks on weathering into the large thin slabs which cover the sides of Cone Butte. The main constituent of the rock is a triclinic feldspar, as revealed by a thin section under the microscope, though occasional crystals of orthoclase of greater size may be observed. Hornblende follows next in order, the crystals being very distinct; and, further than this, magnetite plays an important rôle—this is distributed more generally than is common in similar rocks, and is seen by the microscope as extremely minute grains, whose metallic character is revealed only in reflected light. These particles of magnetite have suffered alteration to a considerable extent, and the feldspar is often stained red and yellow in a ring about them by the oxidized iron. It is to this alteration that the peculiar red color of the talus on the sides of the hills, as seen from a distance, is undoubtedly due. A critical examination shows that a little quartz is also present; but, as it was often otherwise noted in minute cavities, it may be questioned whether it is not merely a secondary product.

The descent from Cone Butte was made by way of the deep ravine which separates it from the trachytic hills to the south. The white trachyte is carried down nearly to the gap, where (see fig. 7) we passed a transverse dike, east and west in direction, of a hard green trachyte, with a cubical fracture breaking into large angular blocks, in striking contrast with the loose slabs of the other trachyte which cover the slopes of Cone Butte. This is probably a later dike, subsequent to the formation of the other hills. This trachyte, as well as that of Cone Butte, was found in fragments abundantly over the prairie, even to a distance of 15 miles from the mountains. It is characterized by large crystals of a glassy orthoclase, which give it a porphyritic structure. Under the microscope, these crystals are found to be more or less clouded, in consequence of incipient alteration; this is also shown by the indistinct colors obtained in polarized light. Accompanying the large crystals of orthoclase are smaller thin-bladed crystals in large numbers. The other essential constituent is the hornblende, which is seen in simple distinct prisms; it has a deep-green color, and is strongly dichroic. No quartz was observed. The most interesting feature of the rock is the green base, which, under a low magnifying power, seems to be without structure, but, when magnified highly, is resolved into countless minute, acicular crystals, jumbled together in a confused mass. They show very little color in polarized light. They may be zeolitic; but a chemical analysis, which the circumstances do not now admit of, would be required to settle the point.

In the ravine spoken of, 355 feet below the summit of Cone Butte, we were surprised to find a series of slates and sandstones. The cut (Fig. 7) will give some idea of the relations of the rocks, it being a sketch taken from a point below to the west. The total width of the gap is about 70 yards; the trachyte rising abruptly on both sides. The trachyte of the hill to the south is quite similar to that of Cone Butte. The section in the gap is as follows:

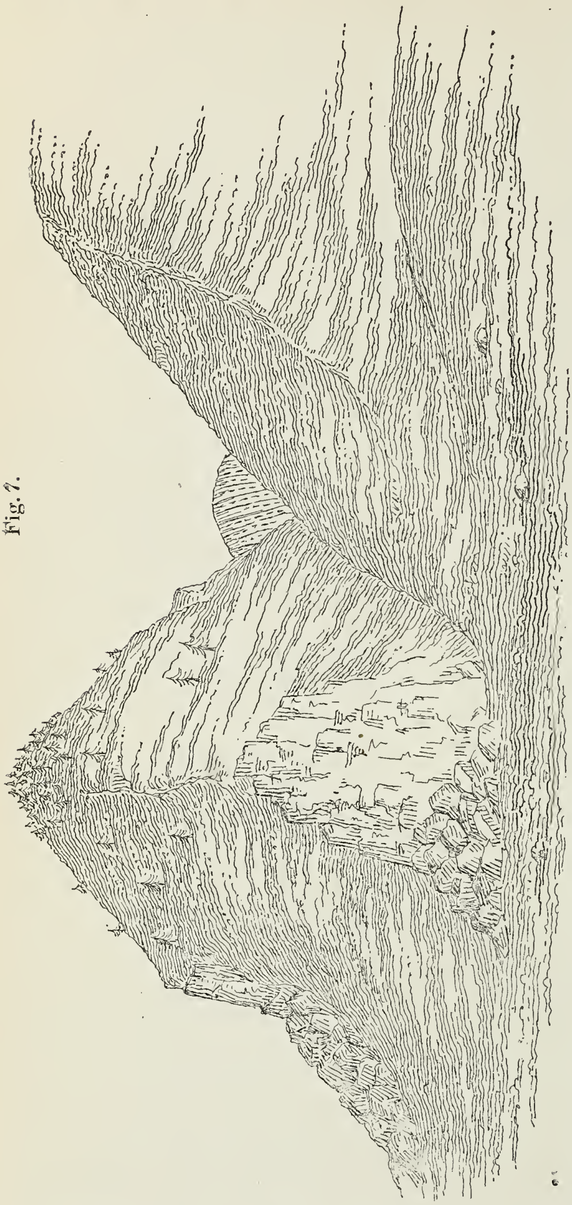
Coarse ferruginous sandstone, vertical	3 feet.
Fine blue shale, vertical	20 feet.
Slate, sometimes shaly, sometimes a good slate, and very sandy, in layers; color, whitish and yellowish; dip, 70° south	180 to 200 feet.

The strike of these slates is east and west.

The age of these rocks is uncertain, as the only fossils found in them were some cycloidal fish-scales, with occasional impressions of fish-vertebræ and spines, which were

quite numerous in some layers in the slate. It is hardly to be doubted, however, that they are Cretaceous; and the position of some rocks, also containing fish-scales, and probably identical with these, observed at another point, as noted below, suggests that they are probably Upper Cretaceous, perhaps No. 5.

Fig. 7.



The present position of these slates is very remarkable; they lie far above (about 600 feet) the rocks visible in the hills below, and doubtless owe their elevation to the eruption of the trachyte, having been squeezed up between the two great masses of igneous rock. They show little trace of the influence of heat upon them.

The hills to the south and east, forming the eastern extremity of the Judith Mountains, are, as far as observed, trachyte. Black Butte, or Buffalo Heart Mountain, was not visited; but its position and similar appearance show that it is also eruptive, probably exclusively so. The sandstones dip away from it even more distinctly than from Cone Butte. It may be remarked here that the trachytic hills are very distinctly marked in appearance, and may be recognized with certainty even at a considerable distance. Their sides are covered with the loose blocks of the rock, and have a distinct reddish color, due to the oxidation of the iron which exists in considerable quantities in the trachyte, (see description,) which is quite conspicuous and characteristic.

West of Cone Butte, (see *e*, Fig. 5,) there is a break in the hills, and a low pass called "Ross's Cut-off" gives passage to frequent Indian parties. It is free from timber, and of gradual slope, so that upon one occasion wagons were brought through without serious trouble. It is from this low pass that Box Elder takes its rise.

In this gap the observarions made were unimportant, the rocks being mostly covered up with soil and grass. It was interesting, however, to note that the even, gradual slope of the terrace before mentioned extends quite into the pass, with the same character well preserved. At *e*, (Fig. 5,) just on the edge of the hills which rise on the west side of the gap, a series of black shales were observed, vertical, and with a strike nearly north and south. These hills at *g* and to the south are all trachyte. We crossed them at one point, dragging our horses over the loose talus, much to their and our own discomfort, and found the height a little less than that of Cone Butte. On their western side the trachyte shows itself in a series of columns, which are very regular and

well formed, much more so than is common in this rock. This trachyte differs somewhat from the others described in the larger proportion of hornblende present. As before, the orthoclase appears in distinct crystals of large size, and the triclinic feldspar in thin-bladed fragments. The whole has a pasty base. A little valley, in which rises a small stream of cool water, lies just to the west, and on the other side is a high limestone hill, (at *h*,) the only exposure of the older sedimentary rocks which we met with in this part of the hills.

This limestone rises in a series of sharp ridges, very distinct, and seen from a distance as a number of white lines running up the sides of the hills. It dips 50° northeast, the strike being northwest. The upper layers are white, semi-crystalline, and very profuse in flinty fragment. These are exposed by the weathering, and, on the surface, the rock has quite a coralline aspect. Lower layers are firmer, blue, and also cherty, though not to the same extent as those above. A very careful search showed that fossils were very rare, though a few were found, enough to determine the age of the rock to be Carboniferous. The following is a list of the fossils obtained at this point:

1. Crinoidal remains too indistinct to be identified.
2. *Terrebratula* or *Cryptonella*.
3. *Spirifera* (*Martinia*) *lineata*, Martin.
4. *Spirifera centronata*, Winch.
5. *Orthoceras*???, possibly filling of outer chamber.

Spirifera centronata, Winch., was the most abundant and characteristic form noticed here.

The thickness of these limestone beds must be very considerable; at least 300 or 400 feet were seen on this side of the hill, but as we were unable to follow them farther we cannot venture to estimate their whole extent. This limestone is intersected at one point by a ridge of hard trachyte. On the other side of the little creek valley, the limestone appears, containing here only a few imperfect crinoidal stems. Here it is apparently overlaid by a sandstone which has all the appearance of dipping under the hill, or, in other words, is overlaid by the trachyte. The outlying hill, *f*, is made up of sandstone, or a sandy slate; its summit is 1,200 feet above Box Elder, and hence a thousand feet lower than the adjoining trachytic hill. The observed thickness of this slate is 200 feet; dip 10° a little east of north, and strike nearly east and west. It can hardly be conformable to the limestone described; but the eruption of the trachyte which doubtless accompanied the elevation of the mountains has very much complicated the relations of the beds.

This slate contained large numbers of poorly-preserved fish-scales, which would seem to show its probable identity with the elevated slates in the ravine behind Cone Butte. Further than this, its position seems to suggest that it may be nearly parallel with the sandstones near Cone Butte, which are, as has been stated, Upper Cretaceous. No trace was seen at this point of any rocks between the Cretaceous and the Carboniferous limestone.

FROM BOX ELDER TO CAMP LEWIS.

The road from Box Elder to Camp Lewis follows along the foot of the mountains, but at such a distance from them that very few observations could be made. The character of the country is much better than that nearer the Missouri, but cannot be very highly praised. The Judith Mountains give rise to several running streams, which occupy wide valleys, and the region seems well adapted for stock-raising. Near Armell's Creek, a mile to the north of the road-crossing, gray clays are conspicuous, forming high bluffs with perpendicular faces, quite different from anything seen near Crooked Creek. This exposure was visited later, on the way to the mouth of the Judith River, but yielded no fossils, and its age is therefore uncertain. It is probably, however, near the top of the Cretaceous.

Our road approached quite near the mountains at Bald Butte, (see *m* on map,) and here, and at several points beyond, we observed a considerable thickness of a soft white sandstone, fine-grained and even-textured, but without fossils. It is in very thick beds, and weathers out in vertical walls, taking fantastic shapes, which are like those of the "Quader Sandstein" of the Saxon Switzerland. This is undoubtedly Upper Cretaceous. From this point the road bears away from the hills again, crossing the divide between the Musselshell and Judith Rivers, and passing between the Judith and Moccasin Mountains. As has been before remarked, the dark clays of the Fort Pierre Group are seen again south of the Moccasin Mountains and just before reaching Warm Spring Creek. At this point there was a considerable exposure of these beds, and, although no fossils were collected here, the characteristic features of the deposit were unmistakable. Farther on, a cut bank on the creek gave the following section:

Yellow clays, somewhat sandy	20 feet.
Hard gray shaly clays seen	20 feet.

These beds had a very slight dip a little east of north.

The Moccasin Mountains we were unable to visit; but their appearance, as viewed

from various points on the road, and again from the northeast, indicated that, like the Judith Mountains, they are largely trachytic.

Camp Lewis is situated on Trout Creek, or Big Spring Branch, as it is sometimes called, which is the largest branch of the Judith River. This is a wide stream of clear, very cold water, which takes its rise in a spring about five miles from where the camp is situated. The immediate valley of the stream is covered with excellent grass, and when the country becomes safe from the incursions of hostile Indians—far from being the case at present—it must prove of high value for settlement.

About Camp Lewis there are considerable deposits of red clay. This is the case on both sides of the stream, but most conspicuously on the east bank, where the bluffs for a considerable distance are of a deep-red color. It is rare to find any exposures of the beds which give rise to these red slopes. In general, they are so washed down that only the red surface-deposits are seen. In some ravines, however, on the east bank of Trout Creek, we found the hardened red clays in place. No fossils could be discovered, though they were searched for with care. These beds seemed to be somewhat irregular and of rather local character. In the place where opportunities for observation were most favorable, we found 10 feet of red laminated clay, underlaid by a gray shale and overlaid by a sandy slate of a brown color. A little farther north, other layers of sandstone were observed, and beneath these some very thick bedded sandstone deposits; the red clays running out entirely. There was nothing to settle positively the age of these deposits. Except in color, they do not resemble the "red beds" of the West, generally referred to the Triassic; and as similar deposits were seen on the slopes of the Snow Mountains, twenty-five miles distant, overlying sandstones containing Cretaceous fossils, (the same was true elsewhere,) as noted later, it is more than probable that they are all Cretaceous in this vicinity. From this point, on our return journey, we made a detour and crossed the west end of the Judith Mountains; and, as we have just stated our observations in the neighborhood of Cone Butte, it may be interesting to add the others in this place.

Passing on from the red beds just mentioned, we crossed a low divide, and came down into the wide valley of a branch of Trout Creek, passing over some more red clays at a little higher level than those seen before. From here, our course was about north; our objective point being some white limestone bluffs conspicuous on the summit of the range. The foot-hills first passed over consisted, as indicated by one or two rock-exposures, of a brown, firm sandstone, in which no fossils were found. It had a dip of 20° away from the hills. These hills, in both directions, are covered with timber and grass, and the rock is rarely seen on the surface.

The limestone bluffs (*l*, Fig. 5) were reached without much clew to the structure of the intervening country having been gained. This limestone stands up in a series of high buttresses, which, with their vertical fronts, are quite conspicuous objects. They show no evidence of stratification or structure. The rock contains occasionally masses of flint, though they are not so conspicuously cherty as those seen near Cone Butte. Some few fossils show that the rock is of Carboniferous age.

The following is a list of those obtained:

1. *Zaphrentis centralis*, Ev. & Shum.
2. *Syringapora mult-attenuata*, McChes.
3. *Stictopora*, sp.
4. *Spirifera centronata*, Winch.

On the hill to the west of this, a broad band of stratified limestone is exposed, in which some similar fossils were found. This same band apparently appears again on the north side of the hill, but here with a changed dip, northwest instead of southwest, pointing to a fold over at this point.

We crossed the higher ridge here, from which we could see off to the east, noting, as before, that the hills to the north are mostly trachyte, while those behind them to the south are as uniformly limestone. Near the source of Deer Creek, we descended into a broad, green meadow, quite surrounded by the hills. At one point, a patch of bright-red soil suggested a return to the red clays before seen. Crossing over by Bald Butte, a hill of trachyte, we reached the road again. The excursion was not altogether a satisfactory one, though showing the presence of the limestone at this point, but, as an investigation into the futher structure of the hills, it was not successful. The difficulty lies in the fact that the hills are principally of igneous origin, and the thrusting in of the trachyte between the sedimentary rocks has destroyed the regular succession in the strata which would otherwise exist. Further than this, while the trachytic hills are mostly bare and rocky, the other hills are, with the exception of the occasional sharp ridges of limestone, covered with grass and timber, so that little can be seen by one who must hurry on and make few stops. Probably two-thirds of the area of the hills is covered with trachyte, of which that found at Cone Butte may be taken as the type.

CAMP LEWIS TO THE JUDITH GAP.

From Camp Lewis the road passes on 30 miles to the Judith Gap, crossing a portion of the country which has some promise of becoming valuable in time. Quite a number

of running streams pass through it, of which Cottonwood Creek, Little Trout Creek, and Buffalo Creek are the most important. The latter becomes dry late in the season. Little Trout Creek is famous for the number and beauty of the trout which it contains. In the immediate vicinity of the streams the grass is excellent, but on the higher prairie it is rather thin. The streams flow fresh and cold from the neighboring Snow Mountains, and could doubtless be used extensively in irrigation. This Judith Basin is a region that has been highly spoken of, and it will no doubt in time furnish farms for hundreds of settlers.

Very little opportunity for geological work is afforded over this portion of the route; for the prairie is much of it almost level, sloping away to the northwest to the Judith River, and giving no exposures of the underlying rocks. Considerable surface-drift is found here, which is entirely local, consisting for the most part of pebbles and masses of a blue limestone, some of them containing Carboniferous fossils. The source of this limestone is to be found in the Snow Mountains, which rise 10 or 12 miles to the east, and from which it has been very abundantly carried off.

A short distance before reaching Ross's Fork, a bluff was examined of a black shade, containing many reddish iron concretions, but no fossils; and a little farther on, to the left of the road, were seen some washed exposures of light-gray shales, also without fossils. Not far beyond, the soil becomes red again; and for a distance of several miles up to the Judith Gap the presence of beds of red clay is indicated. Associated with them was a limestone, impure and knotty, with many veins of calcite. These red-clay beds appear also at the foot of the Snow Mountains, and, as has been said, also at the foot-slopes of the western end of the Judith Mountains. Their thickness seems to be small. They appear to belong to the Cretaceous, which doubtless extends under the grassy prairie from Camp Lewis to the Judith Gap.

SNOW MOUNTAINS.

From Buffalo Creek, 10 miles before reaching the Judith Gap, (that is, north of it,) we made a short detour to examine the west end of the Snow Mountains. This range extends in an approximately east and west direction for a distance of some 20 miles. It is low, like all the other minor ranges. The average height can hardly be more than 2,000 feet above the surrounding prairie. Buffalo Creek takes its rise in the north side of the west end of the range. Following up the stream for a mile and a half from where the road crosses it, we found some outcrops of sandstone, with indistinct vegetable remains, undoubtedly Upper Cretaceous. A little farther—this on the north side—on the hill-tops, there was a gray sandstone; and below it, on the hill-side, a sandstone of a deep yellow color. Both of these broke into irregular, wavy fragments. Dip 10° westerly; strike north 20° east. These, which are in thickness perhaps 60 feet, are probably Upper Cretaceous.

On the opposite (south) side of the stream appears a thinly-laminated sandstone, with a southwesterly dip of 10°, but a strike north 30° west. Beneath this followed the slopes of red soil, pointing to the presence of thin beds of clay beneath, like those at Camp Lewis. Following and underlying this was a firm, thick sandstone, breaking into massive slabs, which covered the top and sides of the hill, giving it much the appearance of having been paved. The strike was as before. Beyond, also south of the creek, a hard, gritty sandstone was noticed, with layers containing a large number of poorly-preserved shells. These were not specifically recognizable, but have been identified as Cretaceous by Mr. Whitfield. Beneath this was what seemed to be a second deposit of the red-clay beds. These last are visible, though not so distinctly, on the opposite side of the creek, where they are followed by about 5 feet of a firm limestone, and that by a considerable thickness of green and black shales, which last may be traced for a short distance on both sides of the stream. It is to be noticed that the strike, and hence the dip, of similar layers on both sides of the stream is quite different; and though further study is needed to make out all the facts, we think it can hardly be doubted that at this western end of the mountains there is a distinct fold—the axis probably running little north of west.

Continuing up to the source of the stream, we found the limestone here with a very slight dip to the northwest; strike northeast. The final point which we reached was a little cañon, with high and bold limestone walls, from which we obtained a few not very perfect Carboniferous fossils, viz:

1. *Zaphrentis centralis* (?), E. V. & Shum.
2. *Streptorhynchus Keokuk*, H.
3. *Spirifera centronata*, Winch.
4. *Stictopora*, sp.

To reach these Carboniferous rocks we had doubtless passed over in succession the Cretaceous rocks, having perhaps a thickness of 900 feet, and also the Jurassic, if it exists here. We found no fossils belonging to this age, and doubt the existence of any considerable thickness of Jurassic beds. The limestone with the green and black shales, noted above, may possibly belong here.

Leaving the ridge, we turned at right angles to it; that is, nearly north. Here we passed over, first, the limestone dipping northwest, then successive beds of sandstone with beds of red clay interstratified. Near the foot of the hill a reversal of the dip occurs in the sandstones, pointing to a minor fold parallel to the general course of the range. No older rocks than the Carboniferous limestone were observed; and from the numerous limestone pebbles containing Carboniferous fossils, picked up at different points along the sides of the mountains, it is safe to conclude that the range, as a whole, is made up of Carboniferous limestone, the younger rocks lying on its outer slopes. No evidence of any older rocks than the Carboniferous was noted; certainly not of any crystalline rocks. The trachyte, so common in the neighboring Judith Mountains, seems to be almost or entirely absent.

LITTLE BELT MOUNTAINS.

The Judith Gap is the divide between the Judith and the Musselshell Rivers. At this point the Little Belt Mountains and the Snow Mountains approach one another quite closely. The former are quite an extended and somewhat irregular range, reaching for a long distance north and west. Of its general geology we can say little, as we can speak only of a few widely-separated points where we were able to visit it. One of these points was the extremity of the range at the Judith Gap. Near the gap we have already spoken of finding, on the north side, beds of red clay, which are associated with a little limestone, and nearer the hills with an underlying sandstone. Crossing the hills which form the extreme eastern end of the range, perhaps a mile west of the gap, we found a bed of yellow sandstone, which contained *Ostrea congesta*, Con.; then, some distance up the slope, a limestone containing corals, and dipping in a northerly direction; then some thin layers of limestone containing *Productus*.

The fossils found here were as follows, the identification by Mr. Whitfield:

1. *Ostrea congesta*, Con.
2. Cyathophylloid coral.
3. *Campophyllum torquium*, Owen ? ?.
4. *Spirifera centronata*, Winch.
5. *Spirifera*, sp. May possibly be *Spiriferina Kentuckensis*.
6. *Productus*, sp. Resembles *P. Wortheni*, H.; but perhaps more nearly related to *P. multistriata*, Meek.
7. *Schizodus*, sp. Nearly or quite *S. Rossicus*, (DeVern.,) M. & W.

Here were seen 20 feet of green and black shales, dipping 50° northeast. From here, as we go up and across the hills, the strike gradually changes, and with it the dip, so that on the south side of the hill we have strata dipping southeast instead of northeast. The succession observed here is from below up:

Limestone, dip 65° south, strike north 70° east	2 feet
Red clays, with purple slates underlying it	10 feet

These beds bend around some 50°, so that in a vertical section they describe a quarter circle.

The upper and central part of the hill consists of limestone, overlaid by a considerable thickness of slates and sandstones, dipping mostly east-southeast. The hill alluded to forms the extremity of this portion of the Little Belt Mountains. Farther along to the west, in the main range, is a limestone which has every appearance of dipping under all the rocks thus far mentioned; it probably corresponds to the firm limestone which forms the lower portion of the Carboniferous as developed in this region. The structure of this hill, thus imperfectly made out, (a hasty run across it while the party was going round being all that circumstances admitted of,) may be better understood upon the statement that it is an anticlinal fold; the axis pointing about north 30° west, and somewhat elevated in this direction. The south side of the fold is apparently the steeper.

JUDITH GAP TO THE MUSSELSHELL CAÑON.

From the Judith Gap to the Musselshell Cañon, a distance of rather more than 40 miles, the underlying rock belongs for the most part to the Upper Cretaceous; the only fossils found having been referred by Mr. Whitfield, as stated below, to No. 5. This district is remarkable, perhaps more so than any other seen by us, for the deep and wide valleys which have been cut through the nearly horizontal rocks, and which lead away from the neighboring range, the Little Belt Mountains. There are now no streams running from the mountains, with the exception of Haymaker's Creek, near the Forks of the Musselshell, and yet the otherwise remarkably level prairie is broken by a number of striking ravines or valleys. These are all alike, in that they show no evidence of any important action by recent running water, but, on the contrary, point to agencies which must have done their work in glacial times. The beds of these valleys, and also, though to a less extent, the prairie above them, are strewn with pebbles and masses of limestone, whose source is in the mountains, only a few miles distant.

Three very conspicuous valleys, one of them a mile wide, with steep banks more than

100 feet in height, are crossed before going 12 miles from the gap. Hopley's Hole is by far the most remarkable of these. A section is given in the following cut. (Fig. 8.)

The width of the coulée at the top is about 1,000 yards. From the level of the prairie on either side there is a steep plunge down; the total depth to the dry bed of the little stream being, according to aneroid-measurements, 150 feet. On the west side, a second terrace of 50 feet in height is very distinct, while on the eastern slope a similar terrace, at about the same height, seems to be indicated; at present, however, there remains only a series of little conical hills, all lying in a continuous line and presenting quite a peculiar appearance. This ravine is now dry, with the exception of a few springs of moderately good water on the west side. The water from these springs moistens the ground for a little distance about the point where they appear, but soon sinks out of sight. In the early part of the year, after the melting of the snow, more or less water evidently runs in the bed of the stream, which is dry in summer; but its erosive power is small, and there is nothing in the present relations which will explain the existence of such an extended valley. Hopley's Hole is important to those who pass over this road, not only as furnishing one of the few sources of water in this part of the route, but also because along the eastern edge of the valley there is here and there a little timber; a few straggling pine-trees which have ventured out into the prairie from the adjoining hills, and which show, by their appearance, that they have here a hard struggle for existence. The western slopes of this ravine, over which the limestone pebbles before mentioned are thickly scattered, are more gradual than the eastern; and, while the former are covered with thin grass, the latter shows a line of exposure of the sandstone which underlies the level prairie here The upper part of this is yellow and quite ferruginous; that below whitish and a little shaly. It varies somewhat at different points; in one place turning into a soft, dark-colored slate in very thin layers. The whole exposure may be 15 or 20 feet in thickness; the sandstone having a very slight south-easterly dip. No fossils could be found, and the rock seemed to be without any special characteristic features, with the exception of pipe-stem pieces of carbonate of lime, which were quite common. They occupied a vertical position, sometimes curving more or less, and were 6 to 15 inches in length; possibly they were holes in the sand made by borers and subsequently filled up.

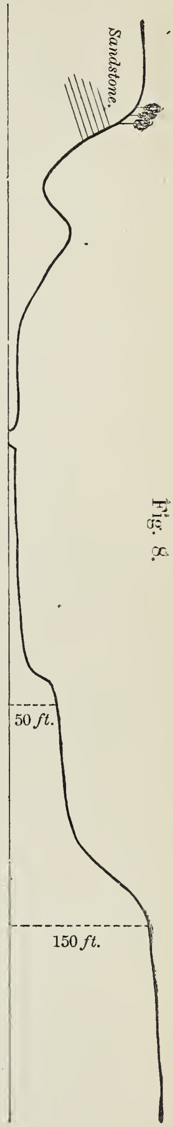


Fig. 8.

A Section across Hopley's Hole.

West of Hopley's Hole, the plain is nearly level for a long distance, broken only by one or two gullies. The general slope of the whole is very gradual to the south toward the Musselshell River and far beyond. In this direction there is nothing to break the view, and the eye wanders unrelieved over a vast range of dry, parched prairie, from which, at midday, the heated vapors arise, producing the illusive phenomena of the mirage.

Haymaker's Creek, 25 miles from the gap, offers another example of the extensive erosion which has taken place in this region. The stream at present carries very little water, and that quite strongly alkaline, especially late in the summer, at which time it barely moves at all. On the west side, the terrace is high and distinctly marked. It may be traced from the mountains to the Musselshell River with the same gradual slope noticed elsewhere; here also quite independent of the dip of the strata, which makes a small angle with its upper surface. On the east side, the slope is very gradual; the final height not being attained for several miles.

A short distance below the road-crossing the sandstone is exposed. For the most part, it is a fine-grained rock of even texture, and of a light-bluish color, becoming yellow on exposure to the weather. Much of this lies in exceedingly thin, paper-like layers. There are also a few layers of a blue, impure limestone, and toward the top a bed of coarse sandstone, almost a conglomerate, containing some indistinct plant-remains, shells, and a few sharks' teeth and vertebræ, which show the beds to be Cretaceous No. 5. The remains are too poorly preserved to be specifically identified. The genera are as follows:

1. *Gryphæa*, sp.
2. *Ostrea*, sp.
3. *Lamna*, sp., (teeth.)
4. *Galeocerdo*, sp., (teeth.)

The strata have a slight dip (5°) northerly; and a little to the north, where the thin-bedded sandstone only is visible, the beds are horizontal or dip slightly to the south. A mile or two farther, *i. e.*, west, we meet several outcrops of a dark ocher-yellow sandstone, in which some pipe-stem calcareous fragments suggested those found at Hopley's Hole. A few indistinct vegetable remains were also obtained, but nothing characteristic. The slight dip is reversed in a subsequent exposure, showing an extremely low fold, the meaning of which will be explained later. Following these are a series of bluffs, sandstones, or sandy shales, some of which we were enabled to visit. None of them afforded us any fossils. Over these, we noticed a few washed exposures of white and cream-colored clays.

These doubtless all belong to the Upper Cretaceous, though, in view of their very slight dip, it would require more time than we had at our disposal to make out their exact stratigraphical relations. In general, it may be said of these sandstone bluffs that they are more tilted as we approach the mountains, and seem to owe their positions to the forces which threw up this range of hills.

On reaching the Forks of the Musselshell, we come into a more attractive region. From the Judith Gap to this point the prairie is almost a desert, dry and parched, and the grass very thin. Both branches of the Musselshell River, however, are fine running streams, and at their union the alluvial country is wide, and susceptible of profitable cultivation. Just before reaching the Forks, we passed a ranch where a system of irrigation had produced excellent agricultural results.

From the Forks our road took us along the north branch of the Musselshell River, and two miles beyond we entered the Musselshell Cañon. The open country here is rough, and is characterized by many step-like ridges of sandstone, on one side steep, showing the edges of the strata, and on the other sloping off gradually, and covered over with grass.

MUSSELSHELL CAÑON TO CAMP BAKER.

The Musselshell Cañon divides the Little Belt Mountains from what is called the Elk Range. It is a narrow mountain-ravine, with steep hills on both sides, which sometimes approach very closely together, and again recede, giving room for a little strip of green meadow-land on the border of the stream. It is, throughout its length of 8 miles, very picturesque, especially near the eastern end, where the abrupt walls and buttresses of white limestone contrast strongly with the dark-green foliage of the pines and spruces. Altogether, it was a most delightful relief from the parched alkaline prairie on which we had made our camps for the preceding fortnight. The waters of the stream are clear and cold, and abound in what is apparently a species of *Coregonus*. This fish rose readily to a fly, affording to some members of the party fair sport, and furnishing a very agreeable variety to the sameness of our daily fare.

On leaving the open country and entering the cañon, we came abruptly upon the Carboniferous rocks. A band of red clay a few feet wide is quite conspicuous at its eastern opening, followed by several others less striking and quite narrow, all red or ocher-yellow. These are interstratified with a sandstone which contains great numbers of *Ostrea congesta*, Con., as identified by Mr. Whitfield. These dip west 50°. Immediately following these are successive layers of limestones and slates, and then several hundred feet of limestone.

From the former beds the following fossils were obtained:

1. Bryozoan, (undescribed.)
2. *Aulopora*, or bases of *Syringopora*.
3. *Zaphrentis centralis*, Ev. & Shum.
4. *Productus semireticulatus*, Mart.
5. *Productus muricatus*, N. & P.
6. *Productus*, sp., probably young of *P. punctatus*.
7. *Productus*, sp., approaches forms referred to *P. Prattenanus*.
8. *Productus multistriatus*, Meek.
9. *Athyris*, sp.
10. *Pinna Ludlovi*, Whitfield, (n. sp.)

The overlying limestone-beds all dip like the others, a little south of west, 50° to 60°. These limestones form a number of high vertical walls and isolated towers, which are worn out into a variety of fantastic forms which have already been alluded to. These are especially conspicuous on the north side of the stream, though similar walls are seen too on the other side in the line of the strike. This limestone is very cherty, the fragments of flint being numerous; and it is to their presence that the rock owes the peculiar forms in which it now appears. The walls show no evidence of structure or stratification. They abound in little cavities and holes, often partially filled with stalactitic masses of carbonate of lime, showing the extent to which the solvent action of water has worked upon them.

A similar relation of the rocks was observed on the upper slopes of the Bridger Mountains; that is, the series of bright-red indurated clays, with a little Cretaceous

sandstone, followed by thin layers of limestone full of Carboniferous fossils, and then 500 feet or more of a firm cherty limestone, weathering out into walls showing no stratification and rarely containing fossils. The limestones are overlaid by (Jurassic and) Cretaceous and underlaid by Silurian. The similarity in the succession of the beds makes it quite certain that the *underlying* rocks at the entrance of the Musselshell Cañon are really the youngest, forming the upper part of the Carboniferous series, while the rocks which follow and overlie, apparently conformably, are older, and, in part at least, Lower Silurian.

The later layers of the limestone, going west through the cañon, have a somewhat different look from those seen farther to the east, being darker-colored and more uniform in appearance. Leaving the limestone, we passed over perhaps a quarter of a mile without finding any rock in place, though on the hill-slopes to the south masses of a hard, reddish quartzite indicate the presence of this as a member of the series. The next exposure reached was an argillitic slate, with veins of quartz, also dipping westerly. The hills for a considerable distance are rounded and covered with grass, exposing no rocks within the limits that we were able to cover.

The prevailing rock, as we continue up the cañon, following the course of this branch of the Musselshell, is a clay-slate, of which there must be a very great thickness, interstratified with some sandstone-beds. The central portion of the range is trachyte, which is very abundant, forming a series of high hills and seriously interrupting our observations in the succession of the strata. Occasional outcrops of sedimentary rocks, principally slates and shales, appear; but as they contained no fossils, and as their succession was everywhere interrupted by the trachyte, their relations to what had preceded remain very uncertain. On the whole, the cañon gives a very fair exposure of the successive rocks, and to one who could do more than take passing notes in riding through it would no doubt yield some important facts.

Leaving the cañon, we emerge into an open rolling country, covered with grass, and with few exposures of the underlying rock. This, as far as could be observed, was a yellowish fragmentary slate, with occasional veins of quartz and calcite. A number of openings have been made by individuals prospecting for metal, but only faint indications of copper were observed. At Copperopolis, a mine has been sunk some 40 feet into this slate, and some very fair copper-ore and a little silver-ore are being taken out. The mine is being worked on a very small scale indeed, only two men being engaged in it; but the ore obtained is sufficiently valuable to pay its way to the East, where (at Baltimore) it is smelted.

Near this point we pass the divide, and descend rapidly to the valley of Deep Creek, leaving the Musselshell behind us, and striking waters that flow into the Missouri near Sun River; that is, above Fort Benton.

The valley of Deep Creek, though here somewhat narrow, becomes rapidly wider as we follow it down to Camp Baker. It is a fertile alluvial plain, and is no doubt susceptible of successful and profitable cultivation. There is as yet, however, no market for cereals in the vicinity, and the grassy meadows are given up to large herds of cattle, which range at will over the valleys and foot-hills. Every settler owns some cattle and horses, and these require little or no care, even in winter. The inhabitants state that they cut no hay for the winter consumption of their stock, nor do they build stables or shelters for them at that season. The animals are said to run out all winter and to keep fat on the standing hay. Montana beef has quite a reputation for excellence west of the Missouri, so that the raising of cattle is likely to prove the most profitable pursuit for the settler until railroads shall have supplied him with a market for other products. Deep Creek, like most of the streams in this neighborhood, abounds in delicious trout and grayling, (*Thymallus*,) both of which attain a large size, sometimes weighing three pounds and more.

To our left, as we come down the valley of Deep Creek, we have the Elk Range high above us, the summits of which consist of trachyte. This has taken many curious forms, as pinnacles and towers, which rise above the timber, and give to the hills a very castellated appearance. An outcrop of purplish-red slate to the left of the road, and dipping 40° southerly, deserves to be mentioned, as its exact counterpart was seen at Camp Baker, 16 miles distant, there overlying the Potsdam limestones. To the right, that is west, were a series of limestone ridges with masses of trachyte interstratified. These beds of trachyte have all the appearance of sedimentary rocks at a distance, so entirely do they conform to the uptilted beds of limestone. These latter have a dip of 40° to the southwest. They have the appearance of the Potsdam limestone beds just spoken of as occurring at Camp Baker, and since, if continuing, their strike would make them appear there, it is hardly to be doubted that they too are Silurian.

The Sulphur Springs are about 17 miles from Copperopolis, and lie at the point where the road to Camp Baker turns at a sharp angle to the west. The springs have a temperature of 150° or thereabouts, and are strongly impregnated with sulphureted hydrogen. They are quite well known through the Territory, and are believed to have the beneficial effects generally ascribed to similar springs, and to be especially valuable in cases of rheumatism, a complaint very common among miners. Considering the vast

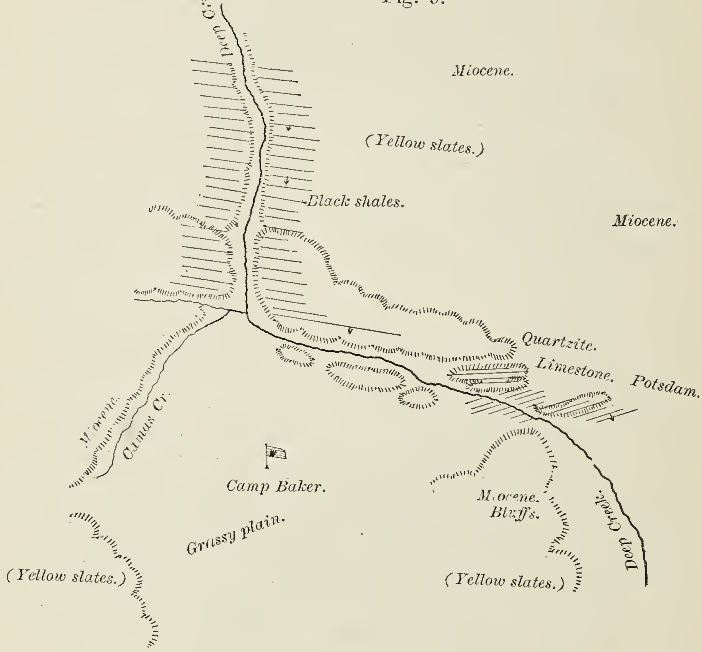
trachytic upheaval which has taken place in that vicinity, the presence of hot sulphur springs can hardly excite surprise.

From the Sulphur Springs the road continues west, at the foot of the Big Belt Mountains, crossing a wide grassy plain, which has an even, uniform slope up to the edges of the hills. The stream, some 10 miles from the springs, where Newland Creek joins it, runs through a gorge of porphyritic trachyte with a distinct columnar structure. This rock borders the creek for some distance, and the dike runs across the road, continuing on in a northerly direction. From here a march of 7 miles took us to Camp Baker, the road passing along by bluffs of Miocene Tertiary, to be described later.

CAMP BAKER.

At Camp Baker, where we made a short stay, we were the recipients of most kind hospitalities from the officer at that time in command there, from whom also we received valuable information in regard to the surrounding country. During the time spent at this point, we were enabled to make an imperfect reconnaissance of the immediate vicinity. The descriptions given below may be better understood by reference to the following cut, (fig. 9:)

Fig. 9.



Camp Baker lies in a broad plain, which is surrounded on all sides by mountains, of which the Big Belt to the south are the most conspicuous and highest. We are here on the eastern border of the mountain-region, which extends far to the westward. The valleys of Deep Creek and its tributaries are filled with deposits of Miocene Tertiary. These consist for the most part of homogeneous cream-colored clays, so hard as to be with difficulty cut with a knife. The lower layers are generally more loose and homogeneous, while the upper beds are harder, firmer, and sometimes quite calcareous. Some of the upper beds are remarkable for the large number of white clay concretions which are found in them.

The beds are horizontal, and rest unconformably on the somewhat upturned yellow and red slates belows; the clays of which they are formed resemble closely those of the Miocene beds at Scott's Bluffs near the North Platte River in Wyoming. The deposits at Camp Baker have been extensively denuded, and nowhere reach any very great thickness. At a point about three miles southeast of the post, some bluffs were noticed where the Miocene beds attained a thickness of 200 feet, and these were capped by 50 feet of Pliocene clays, both beds containing characteristic fossils.

We saw the first exposures of these beds a few miles west of the Sulphur Springs, just after crossing the high ridge of trachyte before referred to, through which Deep

Creek flows. From here, the lake bed was traced continuously along Deep Creek for a distance of 15 miles. Beds of the same character, containing fossils, were found on Spring Creek to the east, on White-tailed Deer Creek, about 7 miles to the north of Camp Baker, as well as on Camas Creek to the southwest. On Camas Creek, the beds are exposed for a mile or more in bluffs ranging from 20 to 25 feet in height. The exposures on White-tailed Deer Creek are much more extensive than those last mentioned. Those on Camas Creek are in thick, rather indistinct, layers, and contain more or less bluish sand in irregular layers, and sometimes a little coarse gravel. Traces of this deposit, containing what appear to be remains of *Rhinoceros*, were also observed two miles or more south of Moss Agate Springs (to be referred to later,) and at a considerable elevation above the creek-bed. With more time than we had at command, they could, no doubt, have been traced much farther, although in many places the beds have been washed out, or have been covered by the later local drift.

In the Miocene beds were found a species of *Rhinoceros;* several species of *Oreodon*, Leidy, and *Eporeodon*, Marsh; a canine tooth apparently of *Elotherium*, Pomel; and remains of Turtles. In the Pliocene beds the principal fossils were a species apparently of *Merychyus*, Leidy; remains of an equine smaller than the modern horse; and Pliocene Turtles. These fossils have not yet been carefully studied, and, for this reason, their relation to the remains found in the other lake-basins of similar age cannot here be stated. The line of separation between the Miocene and Pliocene beds is, in some places, well marked. It consists of about 6 feet of hard sands interstratified with layers of very small, water-worn pebbles, soldered together into a hard mass. Each of these layers is about 6 inches in thickness. Immediately above these strata the Pliocene fossils were found.

It is known that in the neighborhood of Fort Shaw, and near Helena, Pliocene deposits exist; and near Fort Ellis, and in the valley of the Yellowstone, we saw, but were unable to examine, gray sands and marls, which Dr. Hayden refers to the same age. No Miocene beds, however, have been identified at any of these localities. It seems probable that, in Pliocene time at least, the Baker Lake may have extended north to the Missouri River, and perhaps up that stream to the "Three Forks," thus connecting with the lake which existed near Fort Ellis. Indeed, it would seem that we just touched upon the southern edge of this basin, which may have extended far to the north and west.

An interesting point in connection with these deposits is the fact that, with the exception of one deposit in Colorado, they are at a much greater elevation than any other beds of the same age now known on the continent. The elevation of the White River beds is about 3,000 feet, and that of the Oregon basin somewhat less, while that of the deposits near Camp Baker is over 5,000 feet.

On the east side of the plain on which Camp Baker stands the Miocene has entirely disappeared. It is to be noticed that these Tertiary beds were deposited after the elevation of the older rocks, and that most of the denudation now visible in these rocks must have been accomplished before the deposit of the Tertiary, as it is repeatedly seen filling the depressions and unevennesses in the slates, as also covering over the ridges of trachyte. Underlying the Tertiary, and tilted up at a small angle, appear a series of yellow slates and shales, which are quite generally distributed in this region, though not seen elsewhere. They are seen generally as a fine-grained slaty rock, friable and weathering readily, so that exposures of the rock in place are rarely found. Occasionally there are observed in them immense black concretions of remarkable structure. In the interior these consist mostly of a calcareous clay, very hard, and showing distinctly what is called the cone-in-cone structure. Outside of this the lime is purer, though lying in concentric layers, and the exterior shell is made up of fibrous calcite half an inch in thickness. The clay cones radiate from the center of the concretions.

The slates are destitute of fossils, and their age is only a matter for conjecture. The most remarkable feature connected with them is that they have in spots a bright brick-red color; thus, in riding over the country, a patch of intensely red-colored soil will be seen here and there, strongly suggestive of the burned lignite beds of the Missouri River. The slate has at such points the appearance of burned pottery, the material being harder and firmer than the surrounding rock. In some cases the red color was uniform in the rock, but generally it was distributed in successive bands, as though produced by the action of hot water. The red patches quite local, and seldom cover more than a few square yards, though in one case they were seen extending along a range of hills a hundred yards or more. That the effect produced has been caused by the action of heat cannot be questioned, though under what conditions no attempt is made to conjecture. As has been said, these shales and slates are tilted up unquestionably, but their exact relations to the underlying rocks could not be made out without more opportunity for investigation than we had. The difficulty in settling the matter arose from the fact that the loose shale seldom showed its true position.

We find this formation in the immediate vicinity of Camp Baker, both to the east,

where it forms high hills 250 feet above the plain, also to the south and west, where it is intersected by some dikes of porphyry, and quite extensively below in the valley of Deep Creek, as well as along the valley of White-tailed Deer Creek. Its general distribution seems to conform to a certain extent to that of the Miocene Tertiary that is filling the valleys between the older rocks.

The older rocks alluded to form the ranges of hills conspicuous about Camp Baker. Immediately north of the post lies a range of hills, having an east and west trend, through which Deep River takes its course by means of a cañon, which gives an excellent section of the rocks of which the hills are composed. The rocks all dip south, and this dip continues the same for a mile or two to the north. South of the range alluded to, and close to the post, are several minor hills, and, at the distance, a series of others all singularly alike in appearance. The section of rocks alluded to is as follows

Quartzite	20 feet.
A series of colored shales, chiefly red, but also green and blue, with a bed of trachyte interstratified	150 feet.
Two ridges of limestone, in all	80 feet.

These limestones show abrupt bluffs to the north, and dip southerly. In the northernmost of the ridges were found—

1. *Crepicephalus* (*Loganellus*) *montanensis*, Whitf., (n. sp.;)
2. *Obolella*, sp.?;

identifying the formation as Potsdam, according to Mr. Whitfield. Following this is a quartzite, which forms the south side of the hill alluded to. The section is continued through the cañon: quartzite 40 feet, firm and solid, with a reddish tinge of color, breaking into massive blocks; underneath is a series of bright green slates, followed by a variety of clay-slates, mostly dark-colored, with occasional beds of hard, solid quartzite and some thin layers of limestone. After half a mile, the ridge is passed, and the stream comes out into the open country. The rocks, for a mile or two, however, are mostly the same in dip, and are conformable. They are chiefly dark blue shales.

The appearance of the quartzite hills in this neighborhood is peculiar, as they all have a gradual slope to the south, but are nearly vertical toward the north, on which side there is at their foot a talus of large cubical blocks of quartzite.

We were unfortunately not able to visit the Big Belt Mountains.

CAMP BAKER TO FORT ELLIS.

From Camp Baker, the party marched to Fort Ellis; the road for a short distance being the same as that before traveled. The road passes to the right of the Elk Range. Twenty miles from Camp Baker we reached the extremity of this range. At this point we passed immediately from the grassy meadow onto the older rocks. Here we found first a red shale similar to that at Camp Baker, and also to that observed higher up, four miles the other side of the Springs. This was followed by a heavy massive quartzite, a little reddish and very firm; and overlying this was a considerable thickness of limestone. This last is well exposed just above Moss Agate Springs, and in some of the layers we found an abundance of fragments of *Trilobites*. The limestone is much of it very cherty, and in many places it formed the same abrupt and peculiar shapes noticed elsewhere. Just above Moss Agate there is a little superficial synclinal fold in the limestone, the axis of which has an approximately northeasterly direction. Moss Agate Springs takes its name from the fragments of flint, chalcedony, and agate, which are common on the adjoining hills, and many of which, from the presence of the arborescent forms of psilomelane, are popularly called "moss agates."

These fragments of silica are evidently from the limestone, and are quite characteristic of it. Similar fragments of chalcedony, though without the moss effect, were found abundantly in some of the little hills just by Camp Baker. The limestone is evidently the same as that, as is moreover proved by its association with the quartzite and by the few fossils found in it; these were all of one species, a new *Trilobite*,—*Arionellus tripunctatus*, Whitf., (n. sp.)

The road from Moss Agate passes, it is true, more or less at the end of the hills, but at such a distance from them as to afford but little opportunity for observation. From a distance it is observed to how great an extent the hills are made up of limestone, with the conspicuous trachytic prominences before mentioned. From the limestone we pass immediately to a dark, somber sandstone of granular texture and quite peculiar in appearance. This had a dip to the west, and contained some indistinct plant-remains.

On our return journey we found time to touch at the southeastern extremity of the same hills, near the source of Flathead Creek, and here we passed directly from sandstones resembling the one spoken of to the limestone exactly similar to those so often observed at various points in this range. It agreed in all respects with the other exposures. A few indistinct fossils were obtained from a loose block, which had evidently come from close at hand, and these show it to be Carboniferous. They were identified by Mr. Whitfield as *Spirifera centronata*, Winch.

The country near the branch of Deep Creek on the south side of the Elk range is attractive, and covered with good grass, supporting large herds of cattle; but, after passing the low divide which separates the above-named stream, a tributary of the Missouri, from Shields River, a branch of the Yellowstone, a more or less decided change is observed. The prairie is here dry and barren, especially to the south of Cottonwood Creek, and supports nothing but a thick growth of sage-brush. It is watered by several running streams beyond Sixteen-mile Creek, of which Cottonwood is one of the most important, in view of the fact that its banks are fringed with fine trees, from which it takes its name.

As we approach Bridger's Pass the character of the country improves again, and the large numbers of cattle met with near this point indicate its capabilities in the way of grazing. Of the geological relations of this part of the road, we saw little on our way south. While returning, however, our opportunities for observation were better, and the results are presented immediately below. Bridger Pass is a high mountain-divide, thickly wooded, and with the high limestone cliffs of the Bridger Mountains overhanging it on the west side. The scenery is fine, and the change from the bare prairie to the grateful shade of the wooded mountain-side is gladly welcomed by the traveler. Geologically speaking, the prevailing rock is the dark sandstone described later, and known to belong to the Upper Cretaceous. The position of the strata is nearly vertical. An occasional dike of igneous rock was observed, and one of these was conspicuous on the north side of the pass. It consists of a greenish basalt in spherical nodules, separating in the fracture into successive thin slabs. High above the road, as we approach Fort Ellis, we noticed the horizontal strata of the Pliocene Tertiary, which, according to Hayden, extends far away toward the west.

From Fort Ellis the party extended their trip into the Yellowstone Park. We introduce here, however, the additional observations made on our return-trip through the country just mentioned.

BRIDGER MOUNTAINS.

On our return to Carroll from Fort Ellis, early in September, we encountered much trouble at first from the condition of the roads, which were almost impassable, owing to the unprecedented amount of rain that the country had recently received. We made use of the delay which this occasioned in the movements of the wagons to make a little exploration of the Bridger Mountains, or East Gallatin range, as it is sometimes called. These observations could not be extended beyond the east side of the range, and hence are only fragmentary. Considerable time was devoted to the same mountains by Dr. Hayden and his parties in 1871 and 1872, and reference may be made to his reports for those years for the facts observed by them.

This range of mountains is especially conspicuous as viewed from the east side, rising up steeply from the deep and narrow valley, and terminating in a nearly perpendicular white wall, with a sharp knife-edge for its summit. We ascended the ridge from two points: first, September 4, from a point in the valley below, about 6 miles from Fort Ellis; and, again, September 5, from our camp, a short distance to the north side of the divide in the Bridger Pass.

The rock of the valley, and indeed of the pass, as far as observed, is a sandstone of somber tints, gray, brownish, or greenish. The texture is generally granular and gritty, and the rock is more or less speckled with grains of quartz and feldspar. In general, it may be said to be a sandstone made from poorly-assorted materials. It contains in some layers impressions, generally indistinct, of vegetable remains. It is referred, as a whole, to the "Coal Series" by Dr. Hayden, and he further estimates its thickness at 10,000 feet. This seems to us considerably to exceed the truth. We found the same series of sandstones extending in a number of wide folds over the prairie to the north; and this would make it probable that, even if there be a thickness of 10,000 feet of vertical strata belonging here, it has been formed by the pressing together of an anticlinal fold parallel to the range of mountains. This is the more likely, as the strata of the beds all dip steeply and are often overturned, the dip being reversed.

Ascending the hills from the point first mentioned, somewhat north of the Bridger Peak, we passed for a long distance through the timber, crossing here and there little open parks and valleys, up to the foot of the range proper. Up to this point we had seen but few exposures of rock, and those similar to the sandstone already described. The section observed from this point to the summit is as follows: Red earth and clay, with occasional masses of indurated red clay, seldom showing any stratification; in all 60 feet. Following this, and, in its present position, overlying, though, in fact, geologically underlying it, is a thick-bedded sandstone, dipping 60° west; strike north 20° west. This rock was mostly yellow and ferruginous; its texture gritty, at times becoming a mass of coarse pebbles. Occasional layers were calcareous, and contained multitudes of indistinct cretaceous shells. (See list below.) These often yielded to the weather, the rock becoming then rusty and cellular. The visible thickness of the deposit was 40 feet. Then, after a small interval, follows a firm, blue, compact limestone, the first layers containing a few Jurassic fossils, and those following the same in greater numbers. (See list below.) The thickness of this bed is about 60 feet. Following this is a

sandy limestone; and then comes the Carboniferous limestone, which forms the remainder of the upper part of the hill for a distance of 700 or 800 feet, the total thickness of these strata being perhaps 500 feet. This limestone has the same massive and, on weathering, structureless character remarked elsewhere. Some layers seem to be a conglomerate of fragments cemented together by a calcareous paste. Thin layers of dark flint, two or more inches in thickness, are common, running irregularly through the limestone blocks, and also isolated masses of the same rock of greater or less size. At the summit the dip is 70° east. Fossils were not common in this rock; those found were chiefly corals. Continuing along the narrow summit for some distance toward the north, all the time on the solid limestone, we found its dip varying considerably from east to west. On descending, a band of red clay was passed over at the foot of the compact limstone, and calcareous layers interstratified with it contained some Carboniferous fossils. The dip here was west. This is the same band noted on the succeeding day, and to be described farther on. In other respects the return trip added nothing to what had been before observed.

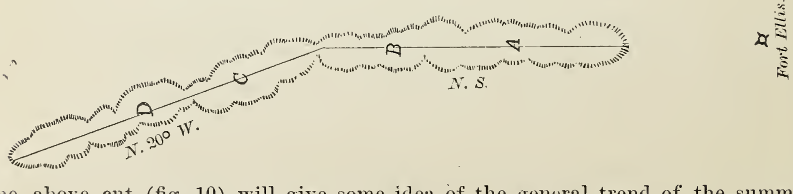
On the following day, the ridge was ascended again from a point some 8 miles beyond, but it did not yield us the complete section of the rocks that we had hoped for. The approach to the mountains was, for the most part, of necessity through the timber, the rock appearing but seldom, and this the dark-colored sandstone before noted. What was observed here would not enable us to do more than guess at its total thickness. Emerging into the open ground, high up on the range, we came upon a high ledge of a very massive, coarse sandstone, or rather a conglomerate. The strike was north and south, and the dip east 35°. The thickness actually exposed was small. Rising 500 feet from here, we found a series of limestone exposures mostly covered with grass. They yielded some Jurassic fossils, similar to those obtained the day before. The rock following was, as before, a white, sandy limestone, sparkling in the sun, and without fossils; then appeared the Carboniferous limestones.

The point we had now reached is conspicuous from all parts of the surrounding country, being marked by two lines of deep red, like bloody gashes, in the side of the mountain. These red bands, though narrow, may be traced along the east slope of the hills for a considerable distance north and south, and form quite a striking feature of the range. The lower bed, made up of an indurated red clay, was only 4 feet in thickness, but the color was very intense. Interstratified with these bands was a small thickness of variegated limestone, generally purplish, sometimes vermilion or greenish. This limestone abounded in Carboniferous fossils; not infrequently the shells occupied the center of little grayish circles in the reddish rock. These soft red bands have generally yielded to denuding influences, and the point where we stood was a narrow neck of land, with a deep gulf opening below us to the south and southeast.

From here to the summit we were on the massive Carboniferous limestone, containing corals and crinoidal plates, with here and there a *Spirifera*. The summit of the ridge attained here was considerably higher than that previously ascended, and was evidently as high as, or higher than, any neighboring point north or south. The aneroid-barometer indicated that the height was in the neighborhood of 10,000 feet. The higher points of the summit were thickly covered with snow, on which were lying thousands of dead grasshoppers; and in many places we saw the tracks of the grizzly bears, which had ascended the range to feed on these insects.

The prospect from this point is exceedingly grand and extended. The ridge, as has been remarked, is, at its summit, extremely narrow, coming to a sharp knife-edge, and the view is unobstructed in all directions. Nearly north and south stretch the irregular summits of this rugged range, while on either side the eye sweeps over the open prairie till arrested by the mountains which rise above the plain. To the east, the Crazy Woman's Mountains are most conspicuous; to the south, the ranges near the Yellowstone River; and westward, the rich Gallatin Valley extends to the "Meeting of the Three Waters;" and far beyond were the Bitter Root Mountains. At the foot of the abrupt cliffs on which we stood was a little mountain lake, far below us, though seemingly at our very feet. With its deep-blue waters, it was prettily set off by the white limestone cliffs above and the dark pines inclosing it on the farther side.

Fig. 10.



The above cut (fig. 10) will give some idea of the general trend of the summit of the range. The points lettered (A, B, C, D) refer to the cuts which follow, showing

roughly the dip of the strata where indicated. No special importance is attached to these, except as showing the irregularity which exists at different points. The younger rocks lie on the east side, the Carboniferous limestones form the summit, and the older

Fig. 11.

rocks are on the west, with a reversed dip. We were unable to extend our observations below the summit, and hence have nothing to add in this relation to what is given in the repoıts already referred to.

The following is a list of the fossils obtained during our examination of these mountains, as identified by Mr. Whitfield:

Cretaceous, September 4 *and* 5.

Ostrea congesta, Con., associated with fragments of carbonized wood.

Jurassic, September 4 *and* 5.

1. *Camptonectes extenuatus,* Meek.
2. *Camptonectes bellistriata,* Meek.

3. *Myacites (Pleuromya) subcompressa*, Meek.
4. *Myalina (Gervillia) perplana*, Whitf., (*n. sp.*)
5. *Gervillia erecta*, M. & H.
6. *Gervillia sparsalirata*, Whitf., (*n. sp.*)
7. *Gryphœa planoconvexa*, Whitf., (*n. sp.*)

Carboniferous, September 4.

Summit.

1. Cyathopylloid coral.
2. Crinoidal plates.
3. *Platycrinus*, sp. ?.
4. *Spirifera centronata*, Winch.

Limestone interstratified with the rea bands.

5. *Productus nebrascensis*, Meek.
6. *Chonetes mesoloba*, Norwood & Pratten.
7. *Athyris*, sp. ?

Carboniferous, September 5.

Summit.

1. *Cystiphyllum*, sp. ?.
2. *Campophyllum*, sp. ?.
3. *Campophyllum torquium*, Owen.
4. *Chœtetes*, sp. ?.
5. *Zaphrentis centralis*, Ev. & Shum. ?.
6. *Syringopora mult-attenuata*, McChes.
7. *Spirifera centronata*, Winch.

Limestone interstratified with the red bands.

8. *Spiriferina Kentuckensis*, Shum.
9. *Athyris planosulcata*, Phil. ?.
10. *Athyris subtilita*, (H.) Meek.
11. *Rhynchonella Osagensis*, Swall. ?.
12. *Streptorhynchus crassus*, M. & W.
13. *Productus punctatus*, Mart.
14. *Productus costatus*, Sow.
15. *Productus Prattenanus*, Norwood.
16. *Productus cora ?*, or perhaps *P. Prattenanus*, Norwood.
17. *Productus*, sp.; may be *P. nebrascensis*, Meek.
18. *Chonetes mesoloba*, N. & P.
19. *Chonetes granulifera*, Owen.
20. *Euomphalus*, sp.

FROM THE BRIDGER MOUNTAINS TO THE FORKS OF THE MUSSELSHELL.

We camped September 5 on Cottonwood Creek, and made from here a short excursion to the west of the road. The main valley of Shields River is a synclinal, lying between the Bridger Mountains and the Crazy Woman's Mountains, with an axis pointing in a direction about north 20° west. In the valley the rocks are rarely exposed; but riding up the creek, two or three miles from the road-crossing, we find the rocks dipping 30° east, with the strike north 30° west. The exposures here show a friable sandstone, disintegrating readily. The rock has a dark, somber appearance, and is made up of a greenish or brownish base, with small grains of quartz and a little feldspar. For a distance of 2 miles, the inclination remains the same; the rock standing up in a series of wave-like ridges, all having an abrupt side toward the west, and a gradual slope to the east. Looking from the eastern side, the existence of the abrupt rock exposures would hardly be expected, so gradual is the rise of the grassy slopes. From the west, on the contrary, the eye is immediately struck by the remarkable series of hills with precipitous fronts.

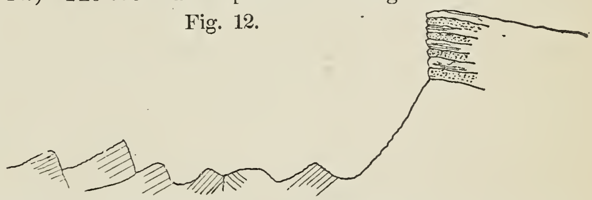
Some 5 miles from the road-crossing, there is a sudden change of dip, and as sudden a return to the easterly direction: this is very probably a local change, occasioned possibly by a dike of igneous rock noticed at that point. The rock is here generally a sandstone, answering more or less closely to the description given above, sometimes a sandy slate, sometimes a whitish-gray sandstone. At the headwaters of Cottonwood Creek, about 6 miles from the road, we found an exposure of a brown sandy slate, full of fucoidal remains, and containing a few indistinct shells. As this rock is apparently one of the lowermost layers in the group of rocks being described, these fossils are of interest as furnishing a clew to the thickness of the strata. The fossils are very poorly preserved, but have been identified by Mr. Whitfield as follows:

1. *Crassatella*, sp.
2. *Crassatella*, near enough to *C. vadosa*, Morton, to have come from New Jersey.
3. *Inoceramus*, sp.
4. *Pholadomya*, sp.
5. *Gryphæa*, sp.
6. *Panopæa*, sp., very near *P. occidentalis*, M. & H.
7. *Scaphites larvæformis*, M. & H.

Scaphites larvæformis is regarded as characteristic of Dr. Hayden's No. 2. Above this bed there must be 5,000 feet of rock belonging to the Cretaceous, though referred in part by Dr. Hayden to the Coal Group.

At the point mentioned we pass a deep grassy valley a few hundred feet in width, and on the other side rises a long range of high bluffs 100 feet above, and extending for a mile or more (see Fig. 12.) The rocks are exposed for a height of from 10 to 50 feet in the perpendicular eastern front of the bluffs, and form a feature of the country quite conspicuous even from a distance. The rock is a brown and gray sandstone in alternate layers, with occasional slaty bands. The dip is here westerly, it being the under part of a very long and low fold. From the summit, quite a good view is obtained to the west; the bluff has an abrupt front both to the east and northwest. The valley alluded to occupies the position of the axis of the anticlinal, and the fold itself is a continuation north of the folding which took place in the Bridger range.

Fig. 12.



Turning north from here, we crossed the divide a mile beyond, and came into a long valley which trends a little west of north. The rock observed here was a brownish-yellow sandstone, with a clay-shale underlying it, and is undoubtedly Cretaceous, though containing no fossils. The valley alluded to drains into Sixteen-mile Creek. We followed it for a distance of 10 miles, keeping along with the strike of the rocks, and found it abundantly covered with thick grass, or rather at this season with hay cured in the ground, which could afford grazing for multitudes of cattle. Turning again easterly, across the strike of the rocks, we cross a long series of wave-ridges dipping east as before, and much resembling those previously observed. A very white fine-grained sandstone forms a series of bluffs not much west of the road.

The valley of the south branch of Deep Creek is wide and level. On the northeastern side, where the road to the Forks of the Musselshell turns off to ascend the divide, there is quite a high ridge, extending from the end of the Elk range across toward the Crazy Woman's Mountains. This valley is obviously, like its continuation below, a synclinal, for the strata dip sharply to the west 70°, the strike being the same northwest. The same dark-colored sandstone forms the first layer; this is underlaid by a sandy slate with large clay cannon-ball concretions. From here on for a mile, the dip is continuously westerly, there being the same series of wave-ridges observed before, only here the dip is reversed, and the abrupt side is toward the east. The strike remains the same, but the dip is gentler, averaging 40°. After some 5,000 feet of strata, the dip is reversed. An exposure of rock on the east side of the trail shows a laminated sandstone, generally soft and friable, but in some places very hard. The dip of the first layers is 30°, and this increases as we proceed to 45°, the inclination being here toward the east or northeast. A mile farther on, near the head of Flathead Creek, we notice another fold. The rock is here a soft yellowish sandstone, dipping west at a small angle, 15° to 20°. This contained many oval clayey concretions, and in the seams in the rock there was more or less calcite. Ripple-marks were noticed in one or two places. Still farther on, the opposite side of the fold is seen, and here it appears that the dark-green and gray rocks seen just after leaving the south branch of Deep Creek underlie the soft yellowish sandstone observed near Flathead Creek. For a mile or two more, we pass over the sandstones, chiefly the dark rock, but occasionally noting beds of the lighter-colored. This latter is much cracked and broken, scaling off into platter-like slabs, so that good exposures of it are seldom seen. Another fold is passed over just before reaching the broad valley of Norton's Creek. We have thus the indications of three great folds between South Deep Creek and Norton's Creek, a distance of 10 miles in a straight line. The strike varies from north to west; the dip is generally as much as 40°, and sometimes much more. A mile or two before reaching Norton's Creek, we pass to the left of a high butte formed by three narrow dikes of eruptive rock, seemingly conformable to the sandstone.

At Norton's Creek, the country changes a little more, and we come upon a broad, fertile, synclinal valley. In this neighborhood, igneous rocks, before rare, become very

common, and beds of trachyte and basalt are repeatedly seen interstratified with the sandstones. The most conspicuous example of this is just to the west side of the meadow through which Norton's Fork flows. Here is a bed of trachyte apparently conformable to the sandstone, and evidently having been erupted between two layers of that rock. It has a semi-columnar structure; the heads of the columns pointing toward the east, thus appearing as if it dipped west, though in reality the sedimentary rocks have an inclination in the opposite direction. In the broad meadow of Norton's Fork, a number of isolated buttes of trachyte may be seen; some of these having taken quite peculiar forms. In these folds, it is seldom possible to trace any single layer of rock, because the characters are not distinctive enough; occasionally, however, this may be done, as in the case mentioned above. A careful plotting of the successive exposures would doubtless show the continuity of the strata, and give an exact estimate of the thickness of the rocks involved, together with the width of each of the folds. This we were of course unable to undertake.

On the east side of Norton's Meadow, the dip is westerly and the strike northwest. Here a brown sandstone is exposed, followed by a gray trachyte in beds, which at a distance look like a solid sandstone, and might easily be confounded with sedimentary rocks. Opposite where the South Fork of the Musselshell is joined by Flathead Creek, is the extremity of a little range of hills, trending northwest, and forming a sort of spur of the Elk range, conforming in direction to the low folds we have been tracing, and seemingly like one of them, a little deeper, and having brought up lower strata. Following the sandstone, which is without fossils, we have, as we cross the east end of this hill, some beds of red clay, making a red soil, but not apparently very thick. Above on the hill is a hard, red quartzite, in massive blocks, which are scattered over the surface of the slope. On the east side of the hill, near the creek, we have several exposures of a gray and yellow sandstone dipping east, strike northwest, followed by a reversal of dip in the same beds. The rocks here observed are a dark ochery-yellow sandstone, firm, and in rather thick layers, and a whitish sandstone, sometimes in very thin, papery layers, sometimes massive, but not often very firm; much the same association as at Hopley's Hole.

The foldings here are not nearly so extensive as those described before; the thickness of rock involved being perhaps not more than 1,000 feet. Near the hill the dip is steep; but a mile from it the inclination becomes very gradual, and insensibly the strata subside, becoming nearly horizontal. A slight eastward dip in the white sandstone is, however, reversed before reaching the Forks, where there is a broad alluvial country. This seems to be the dying out of the action, which was more intense to the westward. Beyond the Forks, on the road to the Judith Gap, (before traveled,) the same brown sandstone and white sandstone are seen again, with a slight dip, which is once more reversed, forming apparently a final fold in our series, though the inclination is so slight that the direction remains uncertain.

Our course along Flathead Creek was very nearly at right angles to the prevailing direction of the strike, so that we had a very good opportunity to observe the relations of the successive folds.

FROM ARMELL'S CREEK TO THE MOUTH OF THE JUDITH.

From our camp on Armell's Creek, a short excursion was made to the mouth of the Judith River; the intention being to make such an examination of the country at that point as our limited time would admit of.

The beds at the mouth of the Judith have been explored only once before, (by Dr. Hayden,) and their age has hitherto been in doubt. We were able to remain but two days in this interesting locality, and the results obtained were of course meager. Enough, however, was seen to establish the age of the beds at this point as beyond a doubt Cretaceous; three members of this division of Mesozoic time having been found there and identified by fossils.

The ravines, which occur so constantly along the Missouri, extend back from that stream but a few miles, except where a river enters it. Tributaries, however, carry the ravines and the accompanying Bad Lands back, sometimes to their sources. The country which may properly be considered as Bad Lands near the Judith is quite extensive, and is of the most rugged and barren character. Each little stream that flows into the Missouri is bordered by a strip of country more or less wide, that is gullied and washed out in deep and precipitous ravines, without vegetation, and generally utterly impassable, except for the bighorn or the wolf.

The Bad Lands on the Judith River extend along that stream for about 25 miles from its mouth, and run back from the river for about 5 miles on each side of the stream. Those on Arrow Creek, which flows into the Missouri a few miles west of the Judith, extend along it for 10 or 12 miles back from its mouth, and have an average breadth of 4 miles on each side of the stream. Those on Dog Creek stretch back into the bluffs for about 15 miles, running over to meet those of the Judith for about 6 miles of this distance, and reaching eastwardly nearly over to Armell's Creek, which also has an extensive system of Bad Lands.

The rocks are chiefly sandstone, quite pure, often quite hard, but occasionally so soft as not to cohere in blocks when removed from the beds. Occasionally, thin beds of an arenaceous limestone are seen, and from these a few fossils may generally be obtained. Yellowish sandy clays and marls also occur toward the base of the bluffs, but without fossils, as far as could be seen, and lacking any distinctive features. Much of the lower portion of the bluffs is concealed by deposits of the Fort Pierre beds, Cretaceous No. 4, which occur all along the Judith River bottom and in many of the ravines, sometimes running far back into the bluffs. These beds agree in all respects with the deposits of that age seen near Carroll, Crooked Creek, and Box Elder. They were the same dark shales, containing the limestone concretions, with *Baculites*, &c., and abounding in the glittering selenite crystals that seem to be peculiar to these beds.

From our camp on Armell's Creek, we followed the Helena road back toward Camp Lewis for 5 miles or more, and then, leaving it, took a course a little west of north, and, passing about 10 miles to the eastward of the Moccasin Mountains, struck the divide between the Judith and Dog Rivers, by which road alone our point of destination could be reached with the wagons. The time occupied in reaching our camp on the Judith was two days; the distance traveled being a little more than 45 miles.

At a point 2 miles north of our camp, on Armell's Creek, an exposure of bare bluffs was noticed, which furnished the following section, from below upward:

	Feet.
Dark-gray horizontally-laminated shales	60
Laminated slightly ferruginous sandstone	12
Soft, whitish clays, about	100
Dark-gray clays, interstratified with layers of impure limestone concretions, about	100
Total	272

The laminated sandstone contains numerous irony concretions, from the size of a pea up to 2 inches in diameter. These are quite soft, and break readily, showing a concentric structure. The sandstone is much weather-worn. The limestone concretions, on exposure to the atmosphere, crack and break up so that the surface of the bluffs is strewn with their angular fragments. They do not particularly resemble the concretions of the Fort Pierre shales seen near Crooked Creek.

Later in the day, to the northeast of the Moccasin Mountains, we passed over a good exposure of the Fort Pierre clays; and about three miles beyond this, but at a much higher level, were seen about 100 feet of white and yellow sandy clays, capped by a thin layer of fine-grained, calcareous, brown sandstone. This latter was found in place only on the tops of the highest hills. A few shells characteristic of No. 4 were found in the Fort Pierre beds, but none of the other exposures examined yielded any fossils. All the beds seen during the day were substantially horizontal.

The divide along which our road took us is for 25 miles a gently-rolling prairie, covered with a fair growth of bunch-grass. It is a favorite feeding-ground for the buffalo; but, when we passed over it, only a few of these animals were seen, although signs of their recent presence were everywhere apparent. As we approach the Missouri River, the divide becomes less and less wide, and the road more winding. Deep ravines and coulées from Dog Creek and the Judith River run back until they almost meet, so that the road becomes narrow and often difficult. About 7 miles from the Missouri River, there is a narrow pass, the only approach for wagons to the mouth of the Judith. Here the divide is only 10 feet wide, and on both sides steep and precipitous ravines run off to the east and west. This backbone continues for 50 or 75 yards, in which distance it turns and twists sharply every few feet. Sometimes the wagon on one side seems to hang over a precipice 100 feet in height, while on the other it grinds along against the face of a sandstone bluff elevated a few feet above the level of the road, or it has to be lowered carefully down an almost vertical slope of 30 or 40 feet, and to be dragged painfully up another as high and steep. From this point, a march of 4 miles over a gently-rolling plateau brings us to the final descent into the Judith River bottom. The road down into the valley is long and steep; the difference in height between the top of the bluffs and the level of the valley being 1,200 feet.

The upper 400 feet of the bluffs are composed almost wholly of beds of sand, white and yellow, nearly pure, interstratified with occasional fragmentary layers of a fine-grained, clayey, brown or red sandstone. The beds of white sand contain a few poorly-preserved Unios and the remains of Dinosaurs (*Hadrosaurus*) and Turtles, (*Trionyx*.) The yellow sands contain many concretions of hard, yellow clay, but are without fossils, so far as examined. All the beds are horizontal, and most of them are quite hard. The white sands in some places change into a laminated white sandstone, and seem to be always overlaid by the brown sandstone. At a lower level, these beds seem to pass into a white, firm, clayey sandstone, which is very hard; but we were unable, in the limited time at our command, to fix the point at which the change took place.

The character of the lowest portion of the beds on the Judith is much obscured by

the presence of the Fort Pierre clays in the valley, and by the washing out of the base of the bluffs and consequent dropping down of the rocks above them. This has taken place almost everywhere along the Judith and the Missouri River at this point; and, in consequence of this, the rocks dip at every conceivable angle and in all directions. A careful examination, however, will serve to convince the observer that all the beds are really horizontal, and that the apparent bendings and twistings of the rocks referred to by Dr. Hayden are due simply to the action of running water. This element has here acted on a scale so enormous as to be almost inconceivable to one who is not familiar with the important part that is played by this agent in denudation in the West.

At a time in the past when the Judith carried much more water than it does at present, the undermining of the high bluffs was constantly going on, just as the higher alluvial banks of the Missouri River are being undermined at present; and as the lowest beds were washed out, the superincumbent rocks slipped down in vast masses. The process, on a small scale, may be seen every day while ascending the Missouri. Besides this, the water, which in spring, from the melting snows and the early rains, is carried by each of the thousand ravines which we find here, not only washes down the sides of the ridges, but works under the bluffs, often boring for itself an underground passage from one coulée to another. Such passages increase in size annually, and finally become so large as not to be able to support the weight of the rocks above, which sink down and fill up the tunnel. It is to these causes, and to these alone, that the apparent irregularity in the strata at this point is owing, and not to any uplifting of the various mountain-ranges which exist in the vicinity. The beds at the mouth of the Judith have been very little, if at all, disturbed by this latter agency.

The Fort Pierre beds form what may be termed the lowest bench of the bluffs along the Judith near its mouth. They have been very much denuded; at one point reaching a height of 560 feet above the river's level, and at other places along the bluffs being apparently wanting. Deposits of this age are found, not only in the main valley of the Judith, but in many little ravines back in the bluffs as well. It is evident that they at some points have been covered by the younger rocks which have dropped down from above. From the facts above mentioned, it is very difficult, if not quite impossible, to get at the lowermost strata of the bluffs; and we were unable to accomplish it satisfactorily at any point.

A considerable amount of surface-drift was noticed in the valley of the Judith and in the ravines running into it. This consists almost wholly of water-worn limestone pebbles, similar in appearance to the limestone observed at the western end of the Judith Mountains, in the Snowy Mountains, &c. One of these drift-pebbles contained *Spirifera centronata*, Winch.

About 2 miles below our camp, and just above the crossing of the Judith, the Fort Pierre beds extend up the foot of the bluffs to a height of about 100 feet. Above these, where the main bluffs become visible, we noted 40 feet of soft, washed, yellowish clays, and over these 18 inches of hard, blue to gray, impure limestone, containing:

1. *Pholadomya subventricosa*, M. & H.
2. *Liopistha* (*Cymella*) *undata*, M. & H.
3. *Thracia Grinnelli*, Whitf., (n. sp.)

This was followed by 15 inches of soft, finely-laminated sandstone, in color from white to yellowish brown; next came 20 feet of soft, yellow clays; and finally a layer of sandy limestone from 3 to 6 inches in thickness, and consisting almost wholly of the following shells, crowded closely together:

1. *Tellina scitula*, M. & H.
2. *Sphæriola Moreauensis*, M. & H.
3. (?) *Callista Deweyi*, M. & H.
4. *Lunatia concinna*, H & M.
5. *Narica crassa*, Whitf., (n. sp.)
6. *Baculites ovatus*, Say.

At a point said to be about one-third of the way up the bluffs on Dog River, the following fossils were collected by two members of the party:

1. *Mactra Warreniana*, M. & H.
2. *Cardium speciosum*, M. & H.
3. *Tellina* (*Arcopagia*) *Utahensis*, M. & H.
4. *Tellina* (*Arcopagia*) *subulata*, M. & H.

They are imbedded in a soft, yellow sandstone. These fossils, most of which are characteristic, and which have been compared by Mr. Whitfield with typical fossils now in the Smithsonian Museum at Washington, indicate the lower portion at least of these beds to belong to Cretaceous No. 5.

At a point a little south of where the road descends into the valley, and about 300 feet above the level of the river, the following section was taken, from below upward:

	Feet.
Hard, gray, laminated sandstone, passing near the top into a softer, yellowish rock	50
Yellow clayey sands	30
Soft, yellow clays	50
Total	130

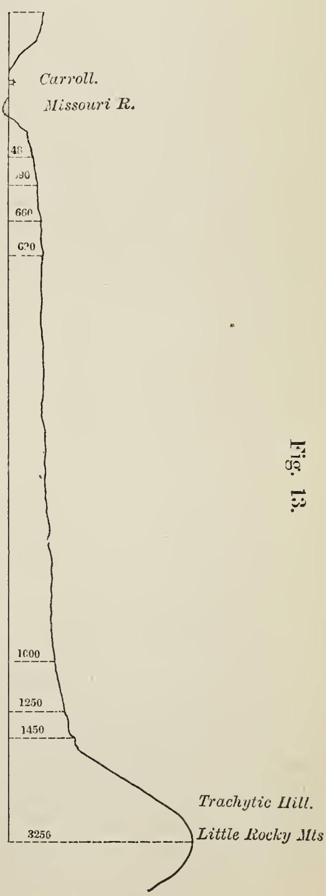
Where the road comes into the valley, a bed of hard, white sandstone, interstratified with layers of yellowish, laminated sandstone, is seen, the whole about 50 feet in thickness. No fossils were found in either of the above.

It may be stated in general terms that the lower two-thirds (or 800 feet) of these bluffs consist of yellowish clays, interstratified with thin layers of sandstone and limestone, and that the upper 400 feet is almost wholly sandstone, more or less hard, generally white, but sometimes varying from that to a dark brown. Lignite occurs in the upper sandstone. A few hundred yards from our camp we noticed a bed of sand 15 feet thick, with several layers of impure lignite from 1 to 2 inches in thickness running through it. This bed had slipped down from some point high up on the bluffs, as it had no connection with the neighboring rocks, and had quite a steep dip. From the fossils obtained, it seems that the upper beds of sands and sandstones must be referred to what have been called the Fort Union beds, or No. 6 of the Cretaceous.

It is a matter of regret to the writers that the observations at this point were so few and so disconnected as to give but little idea of the structure of the bluffs and the relations of the beds. The extent of country to be covered by our observations was very large; and patient study and observation, extended over a considerable time, would have been required to do justice to the locality.

LITTLE ROCKY MOUNTAINS.

A delay of a few days at Carroll on our return journey was in part utilized by a short excursion to the Little Rocky Mountains, which lie about twenty-five miles from the Missouri River, almost due north of that settlement. The starting-point was a short distance below Carroll; and, on reaching the north bank of the stream, we took a trail leading to Milk River, which we were able to follow for some distance. The road rises quite steeply on first leaving the alluvial plain of the river, and attains 400 feet of its final height within a very short distance. From here, the rise is more gradual, the road winding to and fro, keeping on the summit of a narrow ridge, whose sides are washed down steeply on either hand. The washing-out of the bluffs was here even more striking than where observed on the south side of the Missouri; and the continually dividing and subdividing coulées form a labyrinth of little ridges and valleys, which would present a peculiar appearance could they be viewed from a point a few hundred feet directly above. The course for the road, however, has been so well chosen that the ascent is continuous, no descent into any minor ravines being necessary. The final rise is a matter of time, and the high plateau which forms the true bank of the river is only reached after a ride of several miles. The height at this point, as given by an aneroid, was 680 feet above Carroll, which corresponds closely with the similar measurements taken on the other side. After a little comparatively level prairie, the gradual rise is continued, and at the foot of the hills the height is 1,250 feet above the river. A section from Carroll to the mountains is given in Fig. 13, which it is interesting to compare with Fig. 4; the scale is the same.



Profile section from Carroll to the Little Rocky Mountains. Course North and South. Distance direct about 25 miles.

Fig. 13.

The bluffs on the north bank are made up entirely of Fort Pierre shales, and these were observed from time to time nearly up to the mountains. In general character, they do

not differ from those before described. The surface of the prairie as we pass from the river is covered far and wide with drift, very similar to that observed on the south side of the stream; though here the quartzite pebbles are even more numerous, and cover the surface of the ground so thickly as almost to have crowded out the scanty vegetation. Grass is hardly present at all, and even the few weeds have a hard struggle for existence. This is true for 15 miles from the river. Approaching the hills, however, the grass is more abundant; and occasionally in the more favored spots it is sufficiently thick to make it worth the while of citizens of Carroll to come here for hay. In addition to the small, smooth pebbles, the same masses of red and gray syenite found on the Crooked Creek road were seen here. The relations of these will be spoken of more particularly hereafter, (p. 692.) The quartzite pebbles are most numerous within 10 miles of the river-bank, and hardly extend much beyond 20 miles. The same is true of the blocks of crystalline rocks to some extent, though they were seen occasionally quite near to the Little Rockies. It is to be remarked that here also there are no deposits of drift, the pebbles being merely sprinkled over the surface. The nearer we approached the mountains, the more numerous became the slightly washed and rounded fragments of trachyte, containing large, clear crystals of orthoclase. Some fragments of the same rock, by the way, had been seen near Carroll, on the south side of the river. The source of these fragments was obviously to be found in the hills we were approaching, and subsequent exploration proved the truth of this conjecture.

The old trail was left after a time, and we continued on our way, striking across the prairie toward the hills. The country was very dry and barren; the only water seen being in some holes, and that was intensely alkaline. In general, it may be stated here that these hills are very dry, and do not give rise to the numerous running streams which make the region near the Judith Mountains attractive. The level character of the prairie was favorable to the progress of the ambulance, but not at all so for geological investigation; an occasional wash of black shales being the sum-total of all that was observed during a march of 25 miles. As we approached the hills, we passed near to the edge of the high bluffs, which pitched steeply down to the valley of Little Rocky Mountain Creek. The view which was opened out to us was extended and striking, looking down on the Bad Lands of the creek at hand, and those which extended on indefinitely westward. The bed of the stream offered attractions for geological work; but the descent promised so badly for the mules and their load that it was decided to turn away, and keep on the high land.

We made our camp in a meadow some two miles south of the mountains at a spot which furnished a little stagnant water. Here we had the hills in front of us, and on either hand a terrace about 4 miles apart, which stretched southward till they blended with the general level of the prairie. These high terraces, 200 feet above the level of the adjoining plain, are conspicuous features of the landscape, and are important as bearing on the general question of the circumstances under which this country has been denuded. The results of the observations of the following day are contained for the most part in the accompanying sketch. We first examined the strata at the most easterly point, (*a*.) The intervening prairie was doubtless once covered with the upturned strata, but now only isolated patches are to be seen. At *a*, we found a brown massive sandstone, cellular and remarkably honey-combed on the surface, as if worn by water washing against it. Its texture was even, with the exception of numerous rusty iron pellets. It dipped strongly (60°) southerly, strike north 80° east; and, standing up as a high wall or rampart, it had survived the denuding influences which had been too severe for the overlying strata. The outer layer of this sandstone was 12 feet in thickness, and more compact than those that followed; the total thickness being 40 feet. The next exposure was in the coulée 400 yards behind this wall, where followed a series of blue and yellow shales 500 feet in thickness. These had the same direction of strike as the sandstone, but the dip was steeper, becoming nearly vertical, then changing to north. The observations in this direction were cut off by the high hill of trachyte at *b*. The talus from this hill extends out for some distance from it, covering up all sedimentary strata beneath it. At *c* rises a second complementary hill of trachyte, and lying between these two and limiting the prairie in this direction is an imposing limestone wall. This is worth mentioning, for it is so conspicuous an object as to be distinctly visible in clear weather at a distance of 50 miles to the south. The mountains seem from such a point to have a continuous white girdle running around them. This is due to the limestone and to its continuation east and west in the range; the abrupt wall of trachyte also continues this girdle where the limestone is interrupted. The limestone wall shows no stratification, but its face has a steep dip south 70°, and, in character as well as in result of weathering, resembles the Carboniferous limestone so often described.

At the west end of this limestone wall, a little cañon opens out, showing the considerable thickness of the limestone. Lower layers afforded the following fossils, of which a list is here given, with remarks made upon them by Mr. Whitfield:

1. *Glauconome*, sp.?—"Too indistinct for specific determination."

2. *Productus*, sp.?.—"This has a feature (elongated depressions) which is seldom seen in rocks above the Chemung of New York or Waverly sandstone of Burlington, Iowa."

3. *Chonetes*, sp. ?.—Resembles *C. granulifera*, Owen; also very like *C. subumbona*, M. & W.

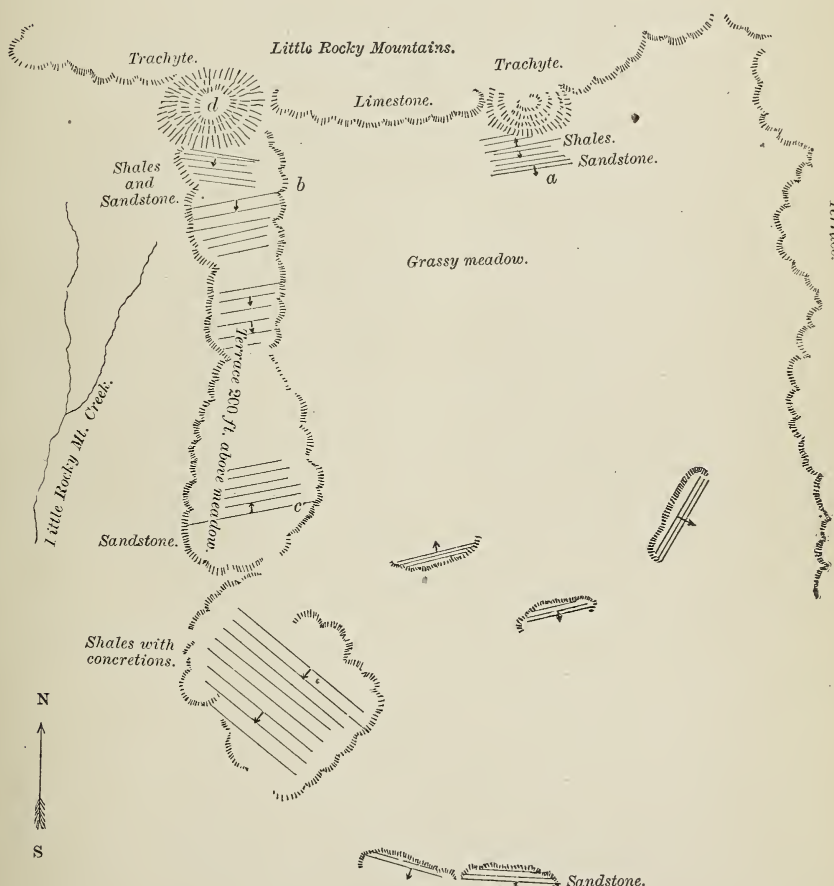
4. *Chonetes*, sp.—"This may possibly be only a variety of the preceding, with which it was associated; but had I seen only this fossil, I should have thought it Lower Silurian."

5. *Spirifera centronata*, Winch.

In regard to these fossils, Mr. Whitfield says:

"The general expression of these fossils is that of Lower Carboniferous, or perhaps Waverly. The locality and formation are worth further exploration in view of the rocks being Lower Carboniferous, or possibly even lower."

Fig. 14.



We ascended the hill at *d* with some little labor, owing to the thick growth of scrub-pines with which it was covered, and from it obtained a fine view of the surrounding prairie and the desert country far to the west. The various ranges of hills were distinctly visible: the Judith Mountains with Cone Butte, to the south, 50 miles distant in an air-line; the Moccasin Mountains; Bear's Paw Mountains, and so on. The height of this hill was 3,500 feet above Carroll, or 2,000 feet above the surrounding prairie. Of the general geology of these hills, little can be said from such a survey, except so far as the wide extrusion of the trachyte was noted. The hill in question was made up of the trachyte which had been found in such large quantities over the prairie to the south. This rock is remarkable for its very porphyritic character, the crystals of ortho-

clase being very numerous and of considerable size, a quarter to half an inch in length. They are usually more or less altered, and under the microscope prove to be made up of minute crystals apparently of a triclinic feldspar, the base consisting of the same material. The whole rock is very white on the fresh fracture, but the little iron it contains oxidizes on exposure, and the surface becomes rusty.

Descending the hill, we pass south over the terrace mentioned before, which would give a good section of the rocks to one who had the time to examine it with care. The lower portion of the southern face of the hill is precipitous; the trachyte showing a bold front. Passing from the talus of the mountain, we came upon a series of variegated shales, mostly bright red, also greenish and blue, evidently baked by the eruption of igneous rock close by; occasional beds of red sand-rock and mud-shales occur with the others. The general strike is shown on the map. The total thickness of these shales was some 800 feet; no fossils were found, only a few indistinct vegetable remains. Overlying these shales, with a slight change of strike, was a thick-bedded sandstone, honeycombed, and in other respects so similar to that described as occurring at *a*, that the identity of the two can hardly be doubted; the underlying shales also correspond. From this point south, the dip became more and more gradual, the terraced hill more grassy, and at *d*, perhaps 2 miles from the hills, the dip is reversed, and the sandstone of *a* and *e* appears with a slight northerly dip. Still farther south and west the hills are more broken, and we passed over a series having a somewhat different strike, consisting of a sandstone, then black shales containing large concretions with selenite plates; and, overlying this, other sandstone layers. This shale suggests strongly the Port Pierre Group, which is seen horizontal only a few miles distant on the prairie. Other exposures of sandstone, yellow and granular, were noted at points to the south, (see figure;) they had a strike and dip as shown in the sketch. These latter are exceedingly similar to those which yielded No. 5 fossils at Box Elder. No fossils were found, however, though it cannot be doubted that the series of rocks belongs mostly to the Upper Cretaceous. Enough has been said to show, with the help of the sketch, that the relations are by no means simple. In general, it may be said that the hills, at least at this point, give evidence of folding; the axis lying east and west, so that the uplifting force must have been from the south. Our return-trip was made by the same trail, and admitted of no further observations.

THE GEYSERS OF THE YELLOWSTONE PARK.

The route followed by the party in going from Fort Ellis to the Yellowstone Lake and Geyser Basins and returning was that generally taken from this point, through the cañon of the East Gallatin River and down the valley of Trail Creek to the Yellowstone River, thence up its valley to the Mammoth Hot Springs, and hence to the falls, the lake, and the geysers. This route has been twice explored by Dr. Hayden and his parties in 1871 and 1872, and the objects of interest in the park have been described in addition in the valuable report of Captain Jones and Professor Comstock, who visited it in 1873. It was not to be expected, therefore, that our hurried trip of nineteen days from Fort Ellis and return would give us any opportunity to collect any important additional facts.

It therefore does not seem to us desirable to attempt here an account of the somewhat disconnected observations we were able to make on our very rapid journey from Fort Ellis to the Geyser Basins, as they must be, in a great measure, repetitions of what has been already published. We may remark, in passing, upon the very great beauty and interest of the whole region, and the wonderful field that it offers for the study of all kinds of modern volcanic rocks.

It seems, however, that it may be of some little interest to record the action of the more important geysers as observed by us during the day or two which we spent in the basins. We do this, not imagining that the facts in themselves have any especial importance except so far as this, that the more the facts in regard to the geysers and their operations are accumulated and recorded, the better will ultimately be the understanding of the phenomena involved.

We reached the Lower Geyser Basin the evening of August 20, and, having at that time and during the following morning but a few hours of daylight in all, we saw no display from the more prominent of the geysers of this basin. The only particularly noticeable eruption observed by us was from the "Architectural" Geyser. The discharge took place in the evening, and was repeated again in the morning, lasting each time about 45 minutes. There was no single stream thrown to a great height; but a continued, confused mass of jets was thrown in all directions, with occasional spirts to a height of 30 or 40 feet. From its very irregularity it seemed to us one of the most attractive of the small geysers. The various other interesting points in the basin, the "Mud Puffs," "Paint Pots," &c., were duly examined, but do not need special mention here.

We arrived at the Upper Geyser Basin August 21, and remained there until the morning of August 24, or about 60 hours. Our note-book gives the following facts in regard to the eruptions of the more important geysers:

Old Faithful, the guardian of the valley, showed a very high degree of regularity during the whole period of our stay. The interval between the commencement of the discharges was 65 or 66 minutes, and, as timed by us for nearly 24 successive eruptions, varied very slightly from this interval. The eruptions were of a very uniform character, differing but slightly in manner or duration (about three minutes) or in the amount of water thrown out. During the night, we were roused each hour by the first rush of the water and steam, and certainly nothing could be more beautiful than this grand fountain in action, illuminated by the light of the full moon. The average height of the column of water, as determined by Mr. Wood, was 115 feet.

The solid portion of the geyser, that is, its ornamented crater, has been much injured by the depredations of selfish visitors, who do not realize that the injury to the crater done by them in a few minutes can never be repaired. One of the most interesting features of this geyser, to one who has recently visited the Mammoth Springs, is the great similarity between the step or basin formation here and that of the calcareous springs, the same cause working here, but under quite different conditions.

Bee Hive.—Our camp was situated in a grove of trees on the Fire Hole River, just opposite the Bee Hive Geyser, so that we were able to observe it under very favorable circumstances. During a period of 60 hours, there were three eruptions; the interval between the first and second being 26 hours, and that between the second and third 25 hours. The duration of the action was four or five minutes, and the measured height 200 feet. The amount of water ejected is comparatively very small; the apparent discharge being greater than the real. This discharge consists largely of steam, which is swayed in one direction and another by the wind; the gracefully-waving column of steam and water producing a beautiful effect. Its charms are considerably enhanced when the sun strikes the jet so as to produce a rainbow near the top of the column. This geyer has a crater alone; there being no step formation at its foot in consequence of the small amount of water which it throws out. The force of the escaping steam and water is very great, and seems almost to shake the crust in the vicinity. A little attendant geyser at the foot of the Bee Hive acts as a sort of forerunner to it, giving notice by its little stream when its larger companion is about to move.

Grand Geyser.—We were fortunate enough to see one very fine display of the action of this geyser. It is especially impressive, because of the absence of any elevated crater; the water rising from the very level of the ground. The height of the first discharge did not much exceed 100 feet. It rose to this point in a series of violent pulsations, remained at this altitude for three or four minutes, and then sank back into the pool, which became quite still. A moment later it had commenced again, the water rising certainly 150 feet by estimate. This again sank down and again rose to its maximum height, and this was twice repeated.

Giantess.—The accounts of the eruptions of the Giantess have been so glowing that we were especially anxious to have an opportunity of observing it ourselves. When we arrived, August 21, the crater was quite full and bubbling, seeming to promise a speedy eruption. The following day at 6.30 a. m., it boiled up vigorously, throwing up jets a few feet into the air, exciting hopes that it was about to perform, and bringing those who were in camp somewhat hastily across the stream. At 9 o'clock it boiled up again, at times throwing out considerable water, so that it was nearly empty as far as we could see, looking far down into the crater. It rapidly filled, however, and a second outburst on a small scale took place. Two hours later a more vigorous display commenced, the hot water being thrown to a height of 100 feet, by a series of successive irregular throbs, like the beats of a pump; the heavy thumping going on below in a startling manner. This irregular display, extremely interesting and beautiful, yet nothing compared with what the Giantess is said to do, lasted for an hour; the entire volume of water thrown out being very great. At length, with a sudden burst, the steam drove up the water to a much greater height than before seen; the noise and concussions accompanying the outburst being very violent. The water was kept at its greatest height for two or three minutes, and for this time we found the Giantess all that had been claimed for it. But the reservoir was almost exhausted, and in a short time the only escape was a mass of steam, which rushed out of the crater with a force which no words could describe.

After we had become somewhat accustomed to the noise of the eruption, and the awe inspired by the vast outburst of steam had in a measure subsided, we experimented upon the violence with which the vapor was ejected by throwing into the crater trunks of trees, logs, and other objects which could be found near at hand, and the height to which these were thrown by the escaping steam was a good indication of the force which was being expended. The heavier of these objects sank nearly to the narrowest part of the crater, and after being held for a moment suspended at this point, rising and falling, according to the violence of the jet which they met, were swiftly shot forth, often rising to a very great height.

This steam-escape lasted for an hour without any sensible diminution in violence, and we could not help regretting that all the water had been ejected before the most

powerful burst of steam had begun, so that we might have had a full display of the power that was at hand acting on the water. The conception of force given by this great steam-escape was perhaps even greater than if it had taken merely the form of a fountain. Six hours later the steam was still escaping, though with somewhat diminished energy, and an occasional liquid jet seemed to show that a little water was draining into the reservoir, only to be immediately ejected.

This great steam-escape is important as bearing upon the general subject of geysers, showing the vast amount of steam which must be accumulated before the discharge can take place, and the high tension under which it must be.

The *Castle Geyser* was active most of the time during our stay, though with varying force. The amount of water discharged was never very large, and the highest jets did not exceed 50 feet.

The *Grotto* was also almost continuously active, and after seeing the injury done to its crater by visitors, the larger majority of whom are residents of the Territory, we could not help wishing that the discharge of boiling water were absolutely continuous, so that the depredators might be kept at a respectful distance.

The *Saw-mill Geyser* played frequently at short intervals, but quite irregularly.

The *Giant* was quiet, occasional spirts of water to the top of the crater being the only sign of latent energy.

GENERAL CONCLUSIONS.

DISTRIBUTION OF THE FORMATIONS.

Pre-silurian rocks.—Up to the time when we reached the Second Yellowstone Cañon, we had seen absolutely nothing of any rocks older than the Primordial series. This is true, not only with respect to our observations made in the several minor ranges of mountains, but also includes the inferences to be drawn in regard to the elevated points not reached, from the absence of any crystalline rocks in the local drift. The only exception to this was at Camp Baker, where the drift contained such masses, doubtless from the neighboring Big Belt Range, which we were unable to visit, but in which we should expect to find a considerable development of the Pre-silurian series.

Granitic rocks have been observed by others on the east side of Gallatin River, but they did not appear within the limits of our observations. The inferred absence of crystalline rocks from the minor ranges of hills, which break through the prairie at different points in this part of Montana, for example, the Judith Mountains, the Snow Mountains, Little Rocky Mountains, &c., if correct would make it improbable that ore-deposits of any economic value should be found in them.

Silurian.—Primordial series.—We observed strata, proved by fossils to belong to the Potsdam, at two localities, and the relations of the rocks at these points, as far as made out, have been described; they may, however, conveniently be recapitulated here.

At Camp Baker, Primordial fossils were found in a limestone hill to the northwest of the post; the series and the estimated thickness are as follows: Quartzite, 20 feet; variegated shales, mostly bright red, also green and blue, 150 feet; limestone, in a double series of ledges, 60 feet; quartzite, reddish, slightly micaceous, then a series of colored slates, mostly green, followed by shales and thin beds of sandstones and limestones, in all probably 1,500 feet; still further conformable shales, 1,000 feet. These extend toward the north farther than we could follow them. It is enough to say that the total thickness of the conformable strata underlying the fossil-bearing limestone cannot be less than 3,000 feet, and is probably much more. All the facts point to a *very great* development of Lower Silurian rocks.

The same rocks were identified at Moss Agate Springs at the south extremity of the Elk Range of mountains; we found here red shales like those at Camp Baker, quartzite and limestone, the latter containing many fragments of *Trilobites*. We were able only to glance at this locality, and consequently the observations stand out isolated. To the Primordial we refer also the rocks underlying (in position overlying, in consequence of an overturn) the Carboniferous limestone of the Musselshell Cañon, of which there must be a thickness exposed of some 1,000 feet. It is also very probable that the limestone and red shales of the east bank of Deep Creek observed in isolated patches belong to the same time. With the exception of the above, no rocks older than the Carboniferous were seen by us anywhere from Carroll to Fort Ellis. It is certainly not to be affirmed positively that they do not exist in the mountains touched at; the contrary is probable, but it is quite certain that, if present, they are in all cases subordinate.

Carboniferous.—Carboniferous rocks are largely and very uniformly developed over this part of the Northwest, as has been remarked by Dr. Hayden. All of the minor ranges of hills, repeatedly referred to, contain Carboniferous limestone to a large extent. In fact, the most striking and characteristic features of all these minor ranges are the walls of white limestone, which stand up conspicuously above the timber, and

attract the attention even from a great distance. The very uniform nature of this limestone has been noted, and to its character in weathering out into steep walls and isolated towers is due the conspicuous appearance mentioned. The general facts in regard to this formation, collating those obtained at different places, may be summed up as follows: The upper portion consists of limestone in thin beds, with layers of shale and a little sandy slate. These upper layers contain fossils more abundantly than the following beds. *Productus*, *Chonetes*, *Spirifera*, *Athyris*, *Rhynchonella*, and *Streptorhynchus* are abundant forms. At the Bridger Mountains, some bands of red clay in the upper part of the formation were very conspicuous and persistent, and suggestions of them were seen elsewhere. At Cinnabar Mountain, in the Yellowstone Valley, the intensely red clays and shale, from which the mountain derives its name, immediately overlie Carboniferous limestone, and belong, as elsewhere, to the upper part of the formation. Below these irregular, thin beds, showing a somewhat different character at different localities, comes the mass of the limestone already many times described. It is firm, bluish white, and always cherty. The flint is sometimes in uniformly-distributed particles of small size, sometimes in broad bands. When acted upon by the weather, the rock takes the form of vertical walls and steep towers, showing no trace of stratification. Reference must also be made to the remarks of Mr. Whitfield upon the fossils found by us at the Little Rocky Mountains. He says: "The general expression of these fossils is that of Low Carboniferous, or perhaps Waverly" To this, we can add nothing, except that the fossils came from a limestone underlying the massive blue limestone before spoken of, containing *Zaphrentis* and other corals in considerable abundance. Except at this point, we found nothing to suggest the possible occurrence of any rocks between the Primordial and the usual Carboniferous.

As to the total thickness of the Carboniferous formation as here developed, we can only hazard a conjecture, which cannot be of very great value. The compact limestone spoken of must be at least 500 feet in thickness, and the total may be 600 feet. At any rate, it is certain that the deposits point to a uniform condition of things at the time when the formation was laid down.

Jurassic.—Jurassic fossils were found on the east slope of the Bridger Mountains at both points where the ascent was made. The only rock observed was limestone, and the fossils were quite abundant, in some layers, at least. The thickness seen was small, and on the one side was a Cretaceous fossil-bearing sandstone, and on the other the undoubted Carboniferous limestone. The interval on both sides was small, and we should regard an estimate of 100 feet for the total thickness as a large one. In regard to this, Dr. Hayden says: "The Jurassic rocks are crushed together in the uplift to such an extent that they are quite obscure, and do not appear to much advantage; but, in Union and Flathead Passes, they are much better exposed." His final estimate of their thickness is not clearly stated; but elsewhere, in the same vicinity, he speaks of them as 1,200 feet thick. Whatever may be the facts at this point, we can safely affirm that the development of Jurassic rocks to the north and east is very limited. We had several opportunities for examining beds possibly Jurassic, in search of fossils; but in no case were we successful in our efforts to find such remains. On the contrary, in two distinct localities we passed from undoubted Cretaceous to undoubted Carboniferous, with a very small interval between of non-fossil-bearing strata. These intervening strata may very possibly belong to Jurassic time, and their apparent absence elsewhere may be due to the disturbing influences of the uplifts; but their relative insignificance seems to us quite certain. Banks of red soil were conspicuous at several points, and in appearance suggested, to a certain extent, the "Red Beds" referred to the Triassic in other localities. In three distinct cases, however, we found such layers immediately underlaid by Cretaceous sandstones; so that we think that the beds in question must belong in all cases to the latter horizon.

Cretaceous.—To the Cretaceous formation belongs the rock underlying the prairie over nearly all of the route traversed by us. We were unable, however, to obtain any satisfactory results as to the succession of the various beds. The sandstones, of which these rocks for the most part consist, are quite different at the various localities at which they were seen. They are generally without fossils, though frequently containing indistinct vegetable remains, and seem to lack any particularly distinctive or characteristic features. They have been so often described in the preceding pages that it is needless here to enlarge upon them. The lower part of the formation must be that visible on the Bridger Mountains, directly overlying the Jurassic. Very little is in sight, however, and the fossils obtained were very poor. When the rocks appear again in the valley, they are mostly the constantly-recurring "somber" sandstones. At the headwaters of Cottonwood Creek, (see p. 122,) we obtained a few poor fossils in a bed which stratigraphically was the lowest in a series of 5,000 feet involved in a gigantic fold. One of these fossils is credited to Cretaceous No. 2 of Meek and Hayden. From here up, in the order of their time, the rocks have been briefly mentioned. They are mostly dark-colored sandstones, occasionally shales, and all nearly destitute of remains of life. The only suggestions of fossils are the indistinct vegetable remains before

mentioned, which were found best preserved in the upper strata. The thickness of this Cretaceous series has been estimated at 5,000 feet. Most of it is referred by Hayden, though without facts, to the doubtful "Coal Group, forming the transition from the Cretaceous to the Tertiary." We regard them all as properly Cretaceous; in fact, in some of the upper strata, fossils belonging to No. 5 were found. As has already been stated, beds of red clay immediately overlie some of the lowest Cretaceous strata; and, though their character is probably local and changeable, they are so noticeable where they occur that they deserve mention here.

Cretaceous No. 4.—The most distinctly-marked and characteristic member of the Cretaceous is No. 4, or the Fort Pierre clays, which have already been fully described. Their thickness was estimated at 700 to 1,000 feet. They extend from Carroll north and south for a distance of 25 miles from the Missouri. Further than this, they were observed below on the river 150 miles from Carroll, and from here to the Judith River, a distance of 200 miles. Beds referred to these take part in the uplifted strata, both at the Judith Mountains and the Little Rocky Mountains, overlaid by Cretaceous No. 5. The Fort Pierre clays were not observed at any greater distance from the river than the points mentioned; and this is true, although beds both below and above them have shared in the folding near the Bridger Mountains. From this it is concluded that the Fort Pierre clays are limited to the immediate valley of the Missouri at this point. In other words, while the conditions were such as to cause an immense accumulation of mud in what is now the immediate valley of the Missouri, different conditions prevailed at a greater distance from the river, and deposits of sandstone were going on.

Cretaceous No. 5.—The Fox Hills Group was determined beyond all question at three points: at Box Elder Creek, near the Judith Mountains; at Haymaker's Creek, near the Forks of the Musselshell; and at the mouth of the Judith River. The rock in each case was a sandstone, which is characteristic of the formation. Upper layers are very yellow and ferruginous, and lower beds white and gray. The local changes are very great. At the Judith Mountains, the thickness of the sandstone, at a point where some estimate of its relation to the underlying clays could be made, was thought to be about 300 feet. North of the Missouri, at the Little Rocky Mountains, sandstones similar to those of No. 5 were seen overlying concretions, and selenite-bearing shales, presumably No. 4; and hence their existence here may be considered probable. If now Cretaceous No. 5 is found at two points, on either side of the river, at a minimum distance of 25 miles, while between is No. 4, and no trace of No. 5, what has become of the latter? One fact observed may be mentioned in this connection: the dark clays are carried from Carroll 100 miles or more down the river; and, at some of the lower points, these clays, which appear alone in the immediate river-bank, have a capping at a little distance of white and yellow sandstone. This observation, made from the deck of the steamboat, is of little value; but it suggests that the No. 5 may be here, where it belongs, directly overlying No. 4, while farther west, in the neighborhood of Carroll, it has been removed by the glacial flood, to be mentioned later.

A more thorough study of the Cretaceous beds at the mouth of the Judith would no doubt have assisted us materially in deciding the point in doubt had we been able to give the requisite time to their examination. As it was, the relations of the beds were, as has been said, somewhat complicated; and we were able to do no more than to identify by fossils the several members of the group exposed at that point. We found here the Fort Pierre clays in close apposition with rocks containing No. 5 fossils.

No. 6. *Fort Union Group.*—Beds of white sandstone, containing occasional layers of a clayey brown sand-rock, were found at the mouth of the Judith River, evidently overlying the beds of No. 5, before referred to. From these deposits of sand, we obtained the vertebræ and long bones of Dinosaurs, identified by Professor Marsh as belonging very near the genus *Hadrosaurus* of Leidy. With these remains were found Unios, and, in some layers, a little lignite; the general association seeming to refer the deposits to the Fort Union beds. Their thickness was estimated at 400 feet, though no sufficient data were collected to warrant any great confidence in this estimate.

Tertiary.—Distinct Tertiary strata were observed in the neighborhood of Camp Baker, and their relations have been so fully described that a repetition is unnecessary. It may be mentioned, however, that the occurrence of a Miocene lake at this point, with beds 250 feet thick, is a matter of no little interest, and opens many interesting questions as to the relations of this with the other well-known Miocene lakes, as also to the Pliocene beds of the Upper Missouri and the Yellowstone Valley. The red and yellow slates, which seem to accompany the Miocene beds of Camp Baker, may possibly be Lower Tertiary, although, as has been remarked, they are not conformable with the overlying beds. In the absence of any decisive facts, however, we must leave this point undecided.

Quaternary.—More or less distinct evidence of Quaternary action was obtained at several points. True traveled drift was observed in the Missouri Valley alone. In Upper Yellowstone region, the amount of material transported has been immense; but the action is, comparatively speaking, local. Fine striæ, presumably glacial, were

seen in the cañon above the mouth of Work Creek, and also in the granitic rocks near the bridge. At the latter point the amount of transported blocks was very large. It may be of interest to note that the blocks apparently from this spot were traced south; and some few scattered bowlders were seen within 1,500 feet of the top of Mount Washburne, as if the action had been in that direction. This matter has been discussed for this locality by others, and we refrain from carrying it further.

The drift at the foot of the Bridger Mountains, the Elk Range, Little Belt Mountains, Snow Mountains, and Judith Mountains, in many cases exceedingly abundant, is in all cases purely local; almost exclusively Carboniferous limestone or trachyte. The masses and pebbles were distributed in the time of glacial flood, when the flow of water from these hills was very great. The action of this flow of water in washing out deep valleys has already been noticed. The special interest attaching to Quaternary phenomena is connected with the facts observed in the Missouri Valley, which have been alluded to, though not described in detail. North and south of the river from Carroll, the prairie is more or less covered with drift-pebbles and masses, whose source is not to be found in the neighboring ranges of hills. On the contrary, the southern limit of this drift is reached 25 miles from the river and about 10 miles from the north limit of the Judith Mountains, where the surface-drift changes its character and commences to be made up entirely of trachyte from Cone Butte and the neighboring hills. To the north, the limit is not so distinctly marked; but it is reached within 20 miles of the river, where the trachyte of the Little Rocky Mountains takes its place. This drift is divided into two classes quite distinct from each other: first, we have the rounded pebbles very uniformly scattered over the surface of the prairie; and, second, the large, angular blocks distributed here and there at random. The pebbles are generally small, sometimes several inches in diameter, but more frequently much less. They are flattened, quite smooth, and in fact bear much the appearance of common stream-pebbles; they are almost never glaciated. They show, however, the marks of the force of attrition by which they have been smoothed into shape, for the surface-layer of those of uniform texture is curiously marked with semicircular cracks, due to the constant blows which they have received against each other, giving them often quite an ornamented appearance. The material of the pebbles is 90 per cent. quartzite, generally yellow, sometimes dull red, (jasper,) and also rarely dark-colored. The remaining 10 per cent. is made up of material so heterogeneous that a catalogue of the varieties would be more curious than valuable; pieces of fossil wood, however, must be mentioned. As has been stated, the deposits are superficial in all cases. The material composing the drift of the second class is very generally a bright-red syenite; this forms masses sometimes 3 or 4 feet in thickness, but averaging about 18 inches. Next in importance is a similar rock, in which the place of the hornblende is taken mostly by black mica; still, again, there are masses of black hornblende rock, a grayish syenite, but very little true granite. All these have a very Archæan look. Masses of semi-crystalline limestone also occur, though not frequently. These blocks, as has been stated, are uniformly angular, showing little trace of wear. They are less uniformly distributed than the pebbles.

The source of these drift-masses can hardly be held in doubt. Confined, as they are, to the Missouri Valley, they make it almost certain that they have been brought by running water in the direction of the present stream. In the flood which followed the melting of the ice, which, to a greater or less extent, doubtless covered the higher mountains, and at a time when the land is supposed to have been depressed, the waters may well have spread over a width of 40 miles, covering the now so nearly level prairie, and could readily have transported the smaller washed pebbles. The large blocks evidently demand stronger agencies, and it is difficult to make any other supposition than that they have been carried by floating ice brought from the westward, from the high mountains which form the main divide of the Rocky Mountains, in which the red feldspar-syenites and the quartzites must have a large development. This would account for their not being rolled bowlders. To the same time of glacial floods belong the formations of the terraces seen; especially those at the Little Rocky Mountains and Judith Mountains.

Our opportunities for making observations above and below Carroll on the river were exceedingly limited. Masses of a syenitic rock were observed, here and there, down the river, prominent at the mouth of the Musselshell River, and again at Fort Peck. Running notes from the steamboat-deck have little value, and not much can be based upon them. Far down the Missouri, near Bismarck, 800 miles from Carroll, the drift bowlders are numerous, and the Quaternary sands form deep stratified deposits. These phenomena, however, join on to those which are observed more and more decidedly to the eastward, and the source of which is to be found to the northeast. West of Carroll, near the mouth of the Judith River, the drift just described was not observed. This evidence is negative merely, since, if once deposited as below, it can easily be imagined that subsequent denudation has obscured it.

It is interesting to note, in connection with the facts stated in regard to the drift

from the westward, the extended and careful observations of a similar character, made at many different points, by Mr. G. M. Dawson, F. G. S., and described in the "Geology and Resources of the Region in the Vicinity of the Forty-ninth Parallel," Montreal, 1875.

If the report in question be consulted, a full description of these interesting facts will be found. It is sufficient for our purposes to call attention to the great prevalence of the quartzite drift over the prairie far to the north of the Missouri. The general character of this drift was much the same as that found by us, and it was also referred to the Rocky Mountains as its source.

PERIOD OF MOUNTAIN-ELEVATION.

Much of the country covered by our reconnaissance is, in some respects, a unique one, as may be gathered from the remarks previously made. The prairie, deeply gullied, as it is, by the Missouri and other minor streams, is, in general, of a pretty level character. The strata are horizontal, and there is little evidence of any elevation since those Cretaceous beds were laid down. Above the prairie, at a number of points, rise ranges of hills of no very great extent, and with an altitude averaging about 2,000 feet. They are seen far and near; and, rising blue and misty in the distance, from the dry, parched level, they are a most agreeable relief to the otherwise unbroken monotony of the landscape. They are important as serving to redeem the country from utter worthlessness, since they give rise to numbers of clear, flowing streams. The Judith Mountains, Moccasin, Highwood, Snow, Little Belt, and, north of the Missouri, the Little Rocky and Bear's Paw Mountains, are the most prominent of these ranges.

Rising, as described, from the level prairie, it is to be expected that they would give good sections of the rocks which once lay horizontal over the whole of this part of the country. This would doubtless be true, could the relations be studied in detail in each case. In fact, however, the extensive denudation has left only remnants of once extensive formations, so that in a given spot the continuity has been much interrupted. Furthermore, the commonly occurring ejection of masses of igneous rocks has served as a decidedly disturbing element.

As to the time when the elevation of our numerous mountain-ridges took place, the evidence, where decisive, points to the same conclusion reached elsewhere in the West, which indeed was to be expected. The time of elevation followed the close of the Cretaceous era. This is clearly seen at the Judith Mountains, where Cretaceous No. 5 has been involved in the general disturbance. The same cannot be questioned for the Little Rocky Mountains. The elevation of the Snow Mountains and the Little Belt Range embraced Cretaceous deposits; and, though it cannot be positively stated that the upper members of the formation came in at these points, this cannot be doubted, in view of the evidence.

The Bridger Mountains are the most interesting and satisfactory. They include strata from the Primordial to the top of the Cretaceous; all apparently conformable, and all elevated at one time. The junction of the Lower Silurian with the Carboniferous did not appear in that portion of the range examined by us.

At the other points where the Silurian was found, we unfortunately could not observe its relations to the overlying Carboniferous. At the Musselshell Cañon, the evidence is not conclusive; but the relations seem to imply conformability from the Cretaceous down to the Primordial. At Camp Baker, the Primordial stands alone; and we saw no evidence of the Carboniferous following it in the sequence of the strata, as would be expected. This fact strongly suggested to us, while on the ground, an earlier elevation of the Silurian; but this cannot be regarded as of much weight, in view of the fact that the extensive deposits of Miocene Tertiary may well cover up what follows and would otherwise be exposed.

DESCRIPTIONS OF NEW SPECIES OF FOSSILS,* BY R. P. WHITFIELD.

Genus CREPICEPHALUS, *Owen.*

Crepicephalus (*Loganellus*) *montanensis*, n. sp.

Plate 1, figs. 1 and 2.

Glabella and fixed cheeks, when united, subquadrangular in outline, contracted across the eyes, and abruptly expanding in front. Glabella narrowly conical, moderately tapering anteriorly, somewhat squarely truncate in front, strongly elevated, and gib-

*The types of all the species here described are in the Peabody Museum of Yale College, New Haven, Conn.

bous in the middle and along the central line, marked by three pairs of lateral furrows, which are directed obliquely backward at their inner ends; anterior pair very short, and placed near the anterior end of the glabella. Occipital furrow only moderately strong. Fixed cheek rather narrow, not exceeding one-third the width of the glabella. Eye-lobes proportionally large. Frontal limb long, equaling half the length of the glabella. No perceptible anterior rim can be detected on the part preserved. Ocular ridges distinct. Posterior lateral limbs long and narrow, their lateral extension about equal to the width of the glabella.

The species is known only by the glabella and fixed cheeks, the latter imperfect; but the form is so unlike any other genus described that there can be no difficulty in recognizing it. The extreme elevation of the glabella is a marked feature.

Locality and formation.—In limestone of the Potsdam Group; overlying quartzite near Camp Baker, Montana.

Genus ARIONELLUS, *Barrande.*

Arionellus tripunctatus, n. sp.

Plate 1, figs. 3-5.

Specimens consisting only of the central parts of the head and separated movable cheeks.

Glabella conical, the height above the occipital furrow equal to the greatest width at the furrow; anterior end rounded, as wide as two-thirds of the length above the occipital furrow; margins defined by strong, well-defined, dorsal furrows; surface moderately convex, and very faintly angular along the median line; marked by three pairs of very faint lateral furrows, which are directed obliquely backward at their inner ends; occipital furrow deep, extending entirely across the base of the head; occipital ring moderately strong, and projecting backward in a central spine of undetermined length.

Fixed cheeks narrow and prominent, but rapidly sloping to the margins in front of the small, prominent, and somewhat pointed palpebral lobes. Frontal limb short, rapidly narrowing at the sides, in front of the eyes, to the anterior furrow, which is deep and strong; anterior to the furrow the limb is suddenly contracted and subangular in the middle; bottom of the furrow marked between the sutural margins by three deep well-marked pits. Postero-lateral limbs narrow at their origin, beyond which they are unknown.

Facial sutures directed forward on a line with the eye for a short distance, when they are directed inward with a strong curvature to the anterior furrow, in front of which they converge more rapidly, and, meeting in the median line, give an angular form to the frontal limb when the movable cheeks are absent. Movable cheeks subtriangular, exclusive of the posterior spine; central area convex; marginal rim strongly rounded and gradully widening from the front, posteriorly to the origin of the spine, which is of moderate strength, and as long as the glabella and frontal limb of the head. Surface of the movable cheeks covered with strong granules. The glabella and fixed cheeks have been similarly marked, judging from the pustulous surface of the cast of these parts. Thorax and pygidium unknown. The surface-structure, together with the well-marked pits in the frontal furrow, will serve to distinguish this from any other known species.

Formation and locality.—In limestones of the Potsdam Group; at Moss Agate Springs near Camp Baker, Montana.

Genus GRYPHÆA, *Lam.*

Gryphæa planoconvexa, n. sp.

Plate 2, figs. 9 and 10.

Shell of medium size; general outline more or less orbicular, or with a straightened, cardinal margin; transverse section plano-convex. Lower valve more or less rounded, often quite ventricose, but sometimes depressed-convex; beak small and narrow-pointed or truncate, usually somewhat twisted, projecting slightly beyond the line of the hinge, and often incurved close to the cardinal border. Upper valve flat or slightly concave, smaller than the other. Ligamental area of the lower valve small; cartilage-groove narrow. Muscular imprints reniform, eccentric. Substance of the shell rather thin and nacreous; surface roughly lamellose.

The form of the shell as seen in several individuals strongly resembles that of an *Anomia;* but, on splitting open one of the specimens, it revealed the features of a

Gryphæa. The general form and characters are so distinct from any known species rom rocks of Jurassic age that it may be readily recognized.

Formation and locality.—In rocks of Jurassic age in the Bridger Mountains, Montana; associated with *Camptonectes bellitriata*, *C. extenuatus*, *Gervillia erecta* M. & H., and *leuromya subcompressa* = *Myacites* (*Pleuromya*) *subcompressa* Meek.

Genus GERVILLIA, *Defrance.*

Gervillia sparsalirata, n. sp.

Plate 2, fig. 8.

Shell small, much below a medium size, very oblique, and rather slender; the axis of the body of the shell forming an angle of not more than twenty to twenty-two degrees with the cardinal line. Anterior wing not determined, but apparently very small or obsolete; posterior wing proportionally long and narrow, the surface flattened and the outer angle very obtuse; body of the shell convex, the left valve much the most rotund, scarcely or not at all curved in its direction. Anterior margin slightly convex; basal margin rounded. Surface of the left valve marked by about five comparatively strong radii, with wider interspaces, those along the middle of the valve strongest and most distant; also by well-marked, crowded, concentric lines, which are more distinct in crossing the radii than between, and on the posterior wing are directed toward the hinge in an almost direct line. Right valve less convex than the left and the markings less distinct.

This species somewhat closely resembles *G. montanensis* Meek, (Geol. Surv. of the Territ's, 1872, p. 472,) but differs very materially in the smaller angle formed by the body of the shell with the hinge-line, and also in the greater length of the hinge. It is possible it may be only a strongly-marked variety of that species, but this can only be satisfactorily determined by more and better specimens. At present, however, it seems impossible to identify it with that one.

Formation and locality.—In rock of Jurassic age at Bridger Mountains, Montana; associated with characteristic fossils of that formation.

Genus MYALINA, *De Koninck.*

Myalina ? (*Gervillia*) *perplana*, n. sp.

Plate 1, fig. 8.

Shell rather above a medium size and erect, elongate quadrangular in outline, with a rounded basal margin; anterior and posterior borders subparallel, slightly diverging from the cardinal margin toward the basal line, which is rather sharply rounded; height of the shell nearly or twice as great as the greatest length in an anterior and posterior direction, and the cardinal border nearly two-thirds as long as the greatest length of the shell. Surface of the left valve very depressed-convex, the anterior umbonal ridge being low and rounded a little within the anterior margin of the shell; beak small, compressed, not projecting beyond the hinge-line. Surface marked by low, rounded undulations, on the body of the shell, parallel with the lines of growth, which become sharper, thread-like lines along the postero-cardinal border.

The depressed and flattened shell, with the subparallel margins and erect form, will readily serve to identify the species. It is possible that the species may prove to be more nearly related to the genus *Gervillia* than to *Myalina* on the examination of other and better specimens; the surface-lining of the shell very closely resembles species of that genus, and the posterior wing is somewhat unlike *Myalina*, while its erect form is quite unlike *Gervillia*.

Formation and locality.—In rocks of Jurassic age at Bridger Mountains, Montana; associated with well-known Jurassic fossils.

Genus PINNA, *Linn.*

Pinna Ludlovi, n. sp.

Plate 1, figs. 6 and 7.

Shell elongate-triangular, very gradually increasing in width from the beaks toward the base; the dorsal and byssal margins diverging at an angle of but little more than twenty degrees. Dorsal margin straight, as long as, or longer than, the body of the shell; basal margin, judging from the lines of growth, nearly at right angles to the

dorsal margin for a short distance, then directed, with a rapidly increasing curvature, to the byssal border. Apex and umbones unknown. Surface of the valves angularly convex, the left one the most ventricose, and the angularity quite perceptible. Both valves are marked, except for a narrow space along the byssal margin, by numerous, very distinct, and somewhat flexuous radiating ribs, strongest in the middle of the shell, and decreasing in strength toward each margin; about twenty-two to twenty-four of the ribs may be counted across the middle of the shell on the specimen figured, most of which are marked along the middle by a distinctly-depressed line. Concentric lines distinctly marked and often forming undulations in crossing the radii. Evidence of minute, scattered, spine-like projections exists upon the surface of the radii. Transverse section across the closed valves angularly elliptical; the relative diameters about as one and two.

The strongly-radiated surface and duplicated ribs are features that will readily distinguish this from other described species.

Formation and locality.—In limestones of the Coal Measures, in the cañon of the Musselshell, Montana.

Genus TAPES, *Mühlf.*

Tapes montanensis, n. sp.

Plate 2, figs. 1 and 2.

Shell small, transversely elongate-elliptical, the length being a little more than twice as great as the height; valves very depressed-convex; beaks subcentral, a little nearer the anterior end, very depressed and inconspicuous, scarcely rising above the general slope of the cardinal border; extremities sharply rounded, the anterior end broadest; basal margin broadly rounded, but a little more arcuate than the cardinal border. Surface of the shell smooth, and presenting the appearance of having been polished, with scarcely perceptible lines of growth.

We know of no described fossil shell very closely resembling this one. *T. Wyomingensis* Meek is perhaps the most closely related, but differs conspicuously in the position of the beaks, which, in that one, are situated only about one-fourth of the length from the anterior end, while in this they are nearly central.

Locality and formation.—In Cretaceous strata near the mouth of the Judith River, Montana, in beds apparently overlying the Fort Pierre shales.

Genus MACTRA, *Linn.*

Mactra maia, n. sp.

Plate 2, fig. 5.

Shell small, subtriangular in outline, with moderately convex valves. Anterior and posterior cardinal slopes nearly equal, the anterior side a little the longest and less abrupt, concave between the beak and the anterior end, while the posterior margin is convex. Anterior extremity narrow, rather strongly rounding upward from the basal margin; posterior extremity subangular; basal line very convex, slightly emarginate just within the posterior angle; beak short, broad, and obtusely pointed, the apex minute, curving, and closely appressed. Body of the shell somewhat regularly convex from beak to base, marked by a strong, subangular, posterior umbonal ridge, behind which the shell slopes abruptly to the margin, and just within which there is a very faintly depressed sulcus extending from below the umbo to the basal line. Anterior umbonal ridge rounded and abrupt.

The specimen from which the description is taken is a partial cast, so that the surface is not perfectly seen; it appears, however, to have been nearly smooth, or with only fine lines of growth. The hinge characters are not clearly made out; the posterior lateral tooth, however, is seen to be long and slender, reaching nearly one-half the distance between the beak and postero-basal angle. The pallial sinus is somewhat rounded, slightly directed upward, and extends nearly to, or more than one-third of the length of the shell from the posterior end.

This species is very similar in general expression to *M. incompta* White, MS., but differs in being longest anterior to the beaks, while the reverse is the case with that species.

Formation and locality.—In beds of the Cretaceous formation believed to overlie the Fort Pierre shales near the mouth of the Judith River.

Genus SANGUINOLARIA, *Lam.*

Sanguinolaria oblata, n. sp.

Plate 2, figs. 3 and 4.

Shell small, transversely broad-elliptical or suboval, widest anterior to the middle of the length, where the width is equal to about two-thirds of the length; extremities broadly rounded, the posterior one most sharply curved; basal margin strongly rounded, most abruptly so anterior to the middle of its length; cardinal margin much less strongly rounded than the basal border, slightly contracted posterior to the beaks, which are small, compressed, and but slightly projecting beyond the cardinal border. Surface of the left valve very depressed-convex, most strongly curved across the shell from beak to base, and, judging from the form, has been more convex than the right valve; posterior end marked by a very faint sulcus passing from behind the beaks to the postero-cardinal margin.

Surface of the shell marked by fine concentric undulations and finer lines of growth.

Formation and locality.—In sandy limestone of Cretaceous age near the mouth of the Judith River, overlying the Fort Pierre shales.

Genus THRACIA, *Leach.*

Thracia (*Corimya*) *Grinnelli*, n. sp.

Plate 2, figs. 6 and 7.

Shell of medium size, transversely broad suboval, nearly equilateral, slightly inequivalve, and apparently a little gaping posteriorly. Basal margin of the shell forming a regular elliptical curve between the points of greatest length; dorsal margin less regular than the basal, slightly contracted behind the beaks; anterior side somewhat rapidly sloping for two-thirds of the distance between the beaks and anterior extremity; extremities sharply rounded, a little less abruptly above than below the middle of the height. Beaks of moderate size, rather broad, slightly projecting above the cardinal line, that of the right valve the largest and extending beyond the left. External ligament small, prominent, and situated close behind the beaks.

Surface of the valves moderately convex, and apparently a little bent in an anterior and posterior direction; the left valve being the most convex. (This is the opposite from what is usually the case.) Valves marked by distinct but irregular and somewhat crowded concentric undulations, and also by a slightly depressed, oblique, somewhat curving sulcus extending from behind the beaks to the postero-basal border, which it scarcely modifies. Internal features and hinge-structure unknown.

The shell bears considerable resemblance to *Thracia Prouti* Meck and Hayden, (= *Tellina Prout* M. & H., Proc. A. N. S. Phil., vol 8, p. 82,) but is less contracted posterior to the beaks, and the dorsal margin slopes more rapidly anteriorly, the shell being less full and rounded on this part; the beaks are also larger, and project above the cardinal line more than in that one; the basal line is also more regularly curved, that one rounding upward more strongly in front and less so behind, giving a straighter postero-basal margin.

Formation and locality.—In rocks of Cretaceous age at the mouth of the Judith River, Montana, which overlie the Fort Pierre shales of that locality.

Genus VANIKOROPSIS, Meek.

Vanikoropsis Toumeyana.

Plate 2, figs. 11–13.

Natica Toumeyana, M. & H., Proc. A. N. S. Phil., vol. VIII, p. 270, 1856.
Naticopsis? Toumeyana, M. & H., ib., vol. XII, p. 423.—Meek, Smithsonian Check-list Invert. Foss., p. 18, 1864.
Vanikoropsis Toumeyana, Meek, Pal. U. S. Geol. Surv. Territ., p. 332, pl. 39, fig. 2.

Shell rather large, naticoid in form, subglobose and a little oblique, composed of about four very ventricose, but not inflated volutions; spire short, depressed, conical, the slope of the spire inclosing an angle of about one hundred and five degrees; suture-line deep and well pronounced; body-volution forming more than two-thirds of the entire height of the shell; aperture broadly oval, rounded, and very slightly extended below, a little straightened on the columellar side, and slightly modified above by the preceding volution; columellar lip thickened and spreading on the body of the pre-

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CREPICEPHALUS (LOGANELLUS) MONTANENSIS.

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ARIONELLUS TRIPUNCTATUS.

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PINNA LUDLOVI.

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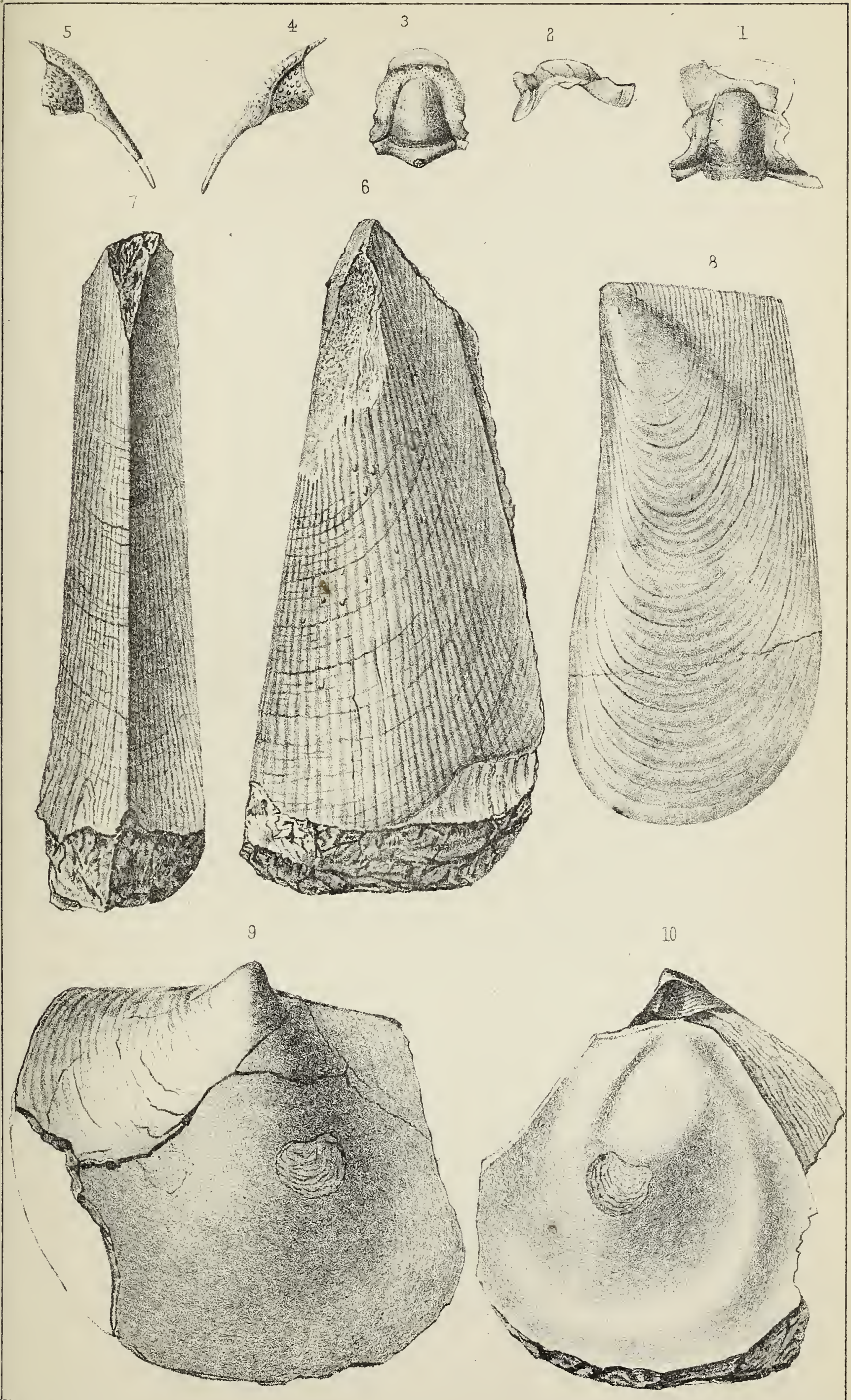
NEW SPECIES OF FOSSILS

Capt. Wm. Ludlow's Exp. to Yellowstone Park, 1875. Plate I.



H. M. Martin, del. T. Sinclair & Son, lith. Phila.

EXPLANATION OF PLATE II.

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MACTRA MAIA.

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GRYPHÆA PLANOCONVEXA.

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VANIKOROPSIS TOUMEYANA.

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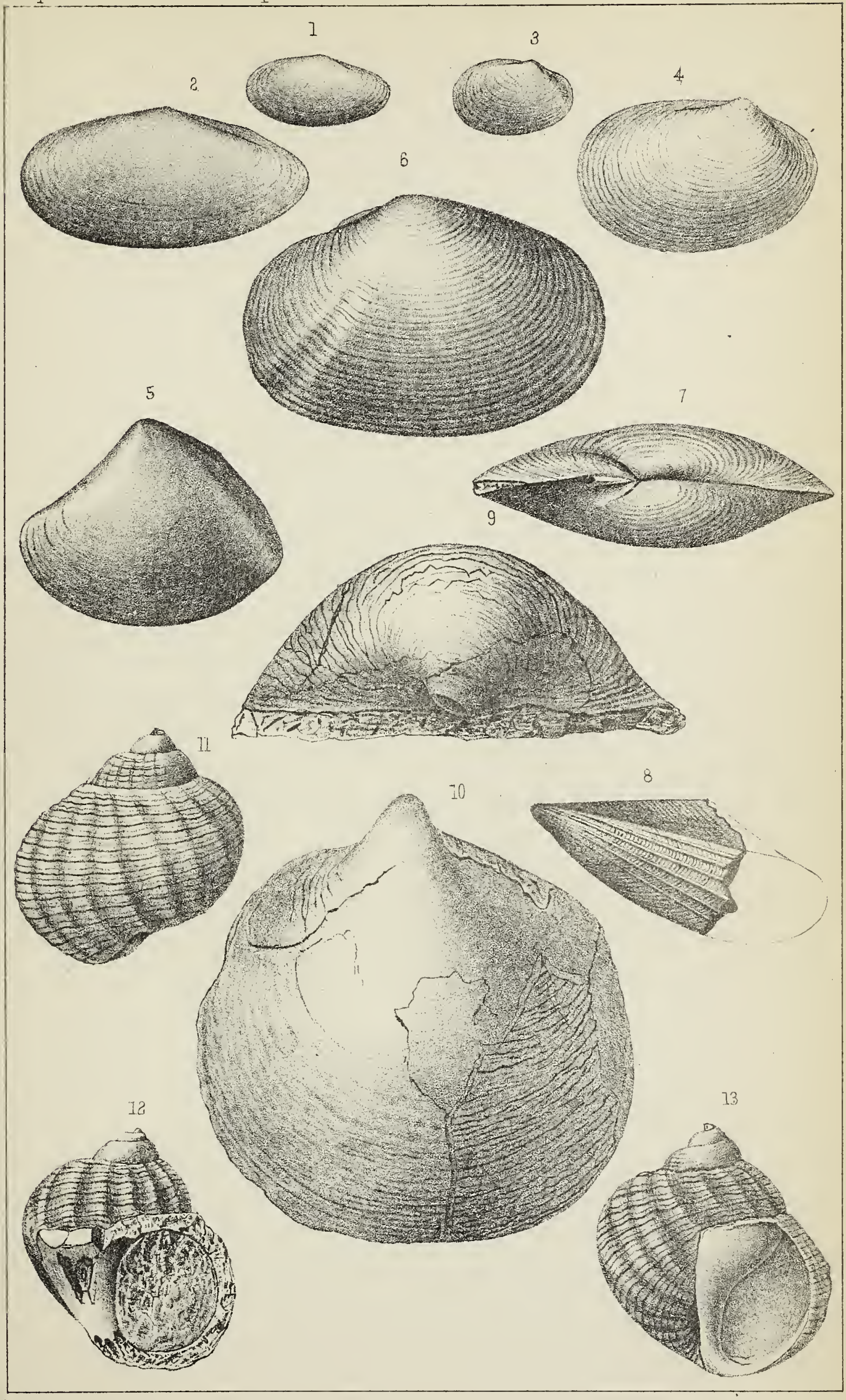
NEW SPECIES OF FOSSILS

Capt. Wm. Ludlow's Exp. to Yellowstone Park, 1875. Plate II



H. M. Martin, del. T. Sinclair & Son, lith. Phila.

ceding volution, and covering but not concealing the umbilicus, or forming a true callus. Umbilicus small and deep.

Surface of the two outer volutions marked by strong, transverse undulations, or ridges, parallel to the margin of the aperture, and numbering about fifteen on the outer whorl; also, by coarse, revolving bands which cross the undulations and have slightly flattened interspaces; four of the bands occupying the space of about one-fourth of an inch on the middle of the outer volution. Substance of the shell very thick and solid.

When describing this species we had supposed it to be entirely new, not having recognized it in the description of the imperfect individual used by Mr. Meek; but on seeing his figure, above cited, we suspect it may only be a more strongly marked individual of that species, and although no direct comparison has been made, we do not hesitate to consider it in that light. It differs, however, in being more elevated and in the stronger vertical folds.

Formation and locality.—In beds of Cretaceous age overlying the Fort Pierre shales near the mouth of the Judith River, Montana.

APPENDIX O O.

ANNUAL REPORT OF LIEUTENANT EDWARD MAGUIRE, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF DAKOTA.

CAMP ON THE YELLOWSTONE RIVER,
NEAR THE MOUTH OF THE BIG HORN RIVER,
July 10, 1876.

GENERAL: I have the honor to submit the following report ot operations in the Department of Dakota from the date of my assignment to duty as chief engineer of the department to the close of the fiscal year ending June 30, 1876:

In obedience to orders received from the Adjutant-General's Office, I reported in person to Brig. Gen. A. H. Terry, at Saint Paul, Minn., on the evening of May 8, and was assigned to duty vice Capt. Wm. Ludlow, Corps of Engineers, United States Army, relieved. In compliance with orders from headquarters Department of Dakota, I left Saint Paul early on the morning of the 10th, and proceeded to Fort Abraham Lincoln, Dakota Territory, to join the troops about to take the field against the hostile Sioux. Mr. W. H. Wood, assistant engineer, with the detachment of enlisted men, had preceded me some days. On arriving at Fort Lincoln, I learned from the commanding general that, unless the services of my assistant were necessary, it was desirable that he should not accompany the column. As his services would have been simply a convenience to me, and in no respect a necessity, I directed him to return to Saint Paul, where he has remained. The detachment of the battalion of engineers, consisting of Sergeant Wilson and Privates Goslin and Culligan, has accompanied me on the expedition, and has performed most excellent service. Sergeant Becker, with two privates, had, previous to my assignment, been ordered to Montana to accompany the column under command of Colonel Gibbon, Seventh Infantry.

After a detention of a few days near Fort Lincoln, due to rain, we finally broke camp at 5 a. m., May 17, and the march westward was

commenced. The column was commanded by Brig. Gen. A. H. Terry, and was composed of the following troops: The Seventh Cavalry, commanded by Lieut. Col. G. A. Custer; a battalion of infantry, commanded by Capt. L. H. Sanger, Seventeenth Infantry; headquarters' guard, consisting of one company of the Sixth Infantry, commanded by Capt. Stephen Baker; a battery of three ½-inch Gatling guns, commanded by Second Lieut. W. H. Low, Twentieth Infantry; 45 Indian scouts, guides, and interpreters, under the command of Second Lieut. C. A. Varnum, Seventh Cavalry; the wagon and pack-trains and herd, with their numerous attachés. There was a total of 50 officers, 968 enlisted men, 190 civilian employés, and 1,694 animals.

I was furnished with a four-mule ambulance for the transportation of my instruments and men. To the wheels of this ambulance were attached the odometers.

The column reached Powder River without having seen an Indian, nor even a trace of recent origin. The only difficulties encountered, with the exception of a snow-storm, which commenced on the night of the 31st of May and lasted until the 3d of June, were those offered by the nature of the country to the passage of a heavily-loaded train. There was not a day that bridging was not necessary; but the journey through Davis Creek to the Little Missouri, through the Bad Lands immediately west of the latter stream, and then the descent into the valley of the Powder, demanded almost incessant bridging and road-making. We reached Powder River late in the evening of June 7. From this camp, Major Reno, Seventh Cavalry, with six companies of his regiment, was sent on a scout up Powder River to the forks, thence across to the Rosebud, and back to the mouth of the Tongue. On June 11, we marched down the valley of the Powder, and reached the Yellowstone, where a depot was established under command of Major Moore, Sixth Infantry. Leaving the wagon-train at this point, Lieutenant-Colonel Custer, with the troops and pack-train, proceeded to the mouth of Tongue River. General Terry and staff went on the steamboat to the same place, there meeting Reno, who reported that he had found a fresh heavy Indian trail, leaving the Rosebud in a westerly direction. The whole command was then moved up the Yellowstone to the mouth of the Rosebud, where we met Gibbon's column. At this point, a definite plan of campaign was decided upon; and, as this plan is clearly set forth in the letter of instruction furnished to Custer, I insert it in full:

CAMP AT MOUTH OF ROSEBUD RIVER,
June 22, 1876.

COLONEL: The brigadier-general commanding directs that as soon as your regiment can be made ready for the march, you proceed up the Rosebud in pursuit of the Indians whose trail was discovered by Major Reno a few days since.

It is of course impossible to give you any definite instructions in regard to this movement, and, were it not impossible to do so, the department commander places too much confidence in your zeal, energy, and ability to wish to impose upon you precise orders which might hamper your action when nearly in contact with the enemy. He will, however, indicate to you his own views of what your action should be, and he desires that you should conform to them unless you shall see sufficient reason for departing from them. He thinks that you should proceed up the Rosebud until you ascertain definitely the direction in which the trail above spoken of leads; should it be found (as it appears to be almost certain that it will be found) to turn toward the Little Big Horn, he thinks that you should still proceed southward perhaps as far as the headwaters of the Tongue, and then turn toward the Little Big Horn, feeling constantly, however, to your left, so as to preclude the possibility of the escape of the Indians to the south or southeast by passing around your left flank.

The column of Colonel Gibbon is now in motion for the mouth of the Big Horn; as

soon as it reaches that point, it will cross the Yellowstone and move up at least as far as the forks of the Big and Little Big Horns.

Of course, its future movements must be controlled by circumstances as they arise; but it is hoped that the Indians, if upon the Little Big Horn, may be so nearly inclosed by the two columns that their escape will be impossible. The department commander desires that on your way up the Rosebud you should thoroughly examine the upper part of Tulloch's Creek, and that you should endeavor to send a scout through to Colonel Gibbon's column with information of the result of your examination. The lower part of this creek will be examined by a detachment from Colonel Gibbon's command. The supply-steamer will be pushed up the Big Horn as far as the forks if the river is found to be navigable for that distance, and the department commander (who will accompany the column of Colonel Gibbon) desires you to report to him there not later than the expiration of the time for which your troops are rationed, unless, in the mean time, you receive further orders.

Respectfully, &c.,

E. W. SMITH,
Captain Eighteenth Infantry, Acting Assistant Adjutant-General.

Lieutenant-Colonel CUSTER,
Seventh Cavalry.

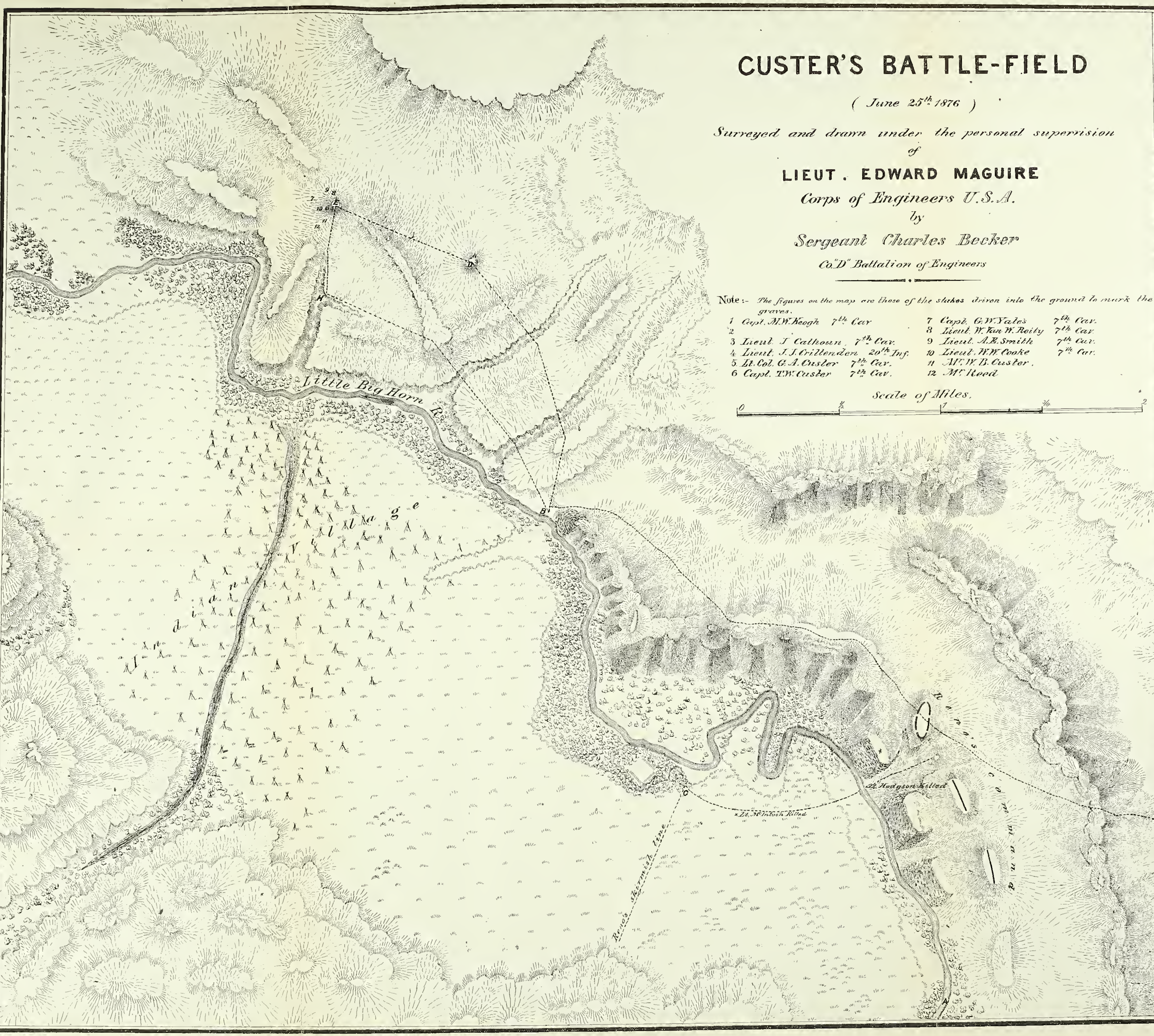
These instructions were supplemented by verbal information to Custer, that he could expect to find Gibbon's column at the mouth of the Little Big Horn not later than the 26th.

Pursuant to these instructions, Custer took up his line of march about noon on the 22d of June. His command (counting officers, enlisted men, and civilians) numbered nearly 650 mounted men. Both man and beast were in excellent condition, and there was not one of the command who was not filled with high hopes of success. Upon Custer's departure, General Terry and staff proceeded up the Yellowstone with Gibbon's column, and when near the mouth of the Big Horn the command was crossed to the right bank of the former stream. Gibbon's column, as now constituted, consisted of four companies of the Second Cavalry, five companies of the Seventh Infantry, and Lieutenant Low's Gatling Battery, amounting in all (including the civilian employés) to 377 fighting men. The night of June 24 we passed in camp on Tulloch's Creek. The next day we crossed the divide between Tulloch's Creek and the Big Horn, and reached the latter stream after a severe march of twenty-two miles. The country was exceedingly rough, hill after hill and ravine after ravine, with but little grass and plenty of the ubiquitous sage and cactus. The soil was alkaline, and the air was filled with dust, clogging up the nostrils, ears, and throat. In addition to this, the day was very warm, and not a drop of water to be obtained on the march. The infantry had understood that we were to follow Tulloch's Creek, and knowing that in that case they could obtain water at any time they did not fill their canteens. The consequence was that they suffered terribly, and numbers of men toward the close of the march dropped on the way, utterly exhausted. The refreshing sight of the Big Horn finally gladdened their hearts, and those left on the road having been brought in, they remained in camp that night. General Terry, taking the cavalry, pushed on, and a most wearisome and disheartening march we made of it. The night was black, and a cold rain drenched us. Besides this, we were obliged to cross a very rough country; and the descent and ascent of steep declivities, with no other guide than an occasional white horse, (if so lucky as to get directly behind one,) was anything but pleasant. The Indian scouts finally found a pool of alkaline water after a march of 12 miles, and we encamped in the mud for the short remaining portion of the night. About 11 o'clock the following morning (June 26) we were joined by the infantry near the mouth of the Little Big Horn, and we then proceeded up the

valley of that river. We went into camp that night only after the infantry had made a march of more than 50 miles in two days. The next morning the march was resumed, and we soon sighted two teepees in the valley. These teepees were filled with dead warriors, and were all that remained standing of a large Indian village. We found the ground strewn with skins, robes, camp-equipage, &c., indicating that the village had been hastily removed. The cavalry-saddles and dead horses lying around gave us the first inkling of the fact that there had been a fight, and that the troops had been worsted; but we were not prepared for the whole truth. As we passed on, we were met by Lieutenant Wallace, of the Seventh Cavalry, who informed us that Major Reno, with the remnant of seven companies, was intrenched on the bluffs across the river, where he had sustained a siege for nearly two days. We ascended the steep bluffs, and the welcome we received was such as to move even the most callous. Officers and men relieved their surcharged natures by hysterical shouts and tears. The question then arose on all sides, "Where is Custer?" The reply came only too soon. About 3 miles below Reno's position, we found the hills covered with the dead bodies of officers and men.

Of Custer's fight we at present know nothing, and can only surmise. We must be content with the knowledge gleaned from the appearance of the field, that they died as only brave men can die, and that this battle, slaughter as it was, was fought with a gallantry and desperation of which the "Charge of the Light Brigade" cannot boast. The bodies, with but few exceptions, were frightfully mutilated, and horrors stared us in the face at every step.

I proceed to give the details of Custer's march from the Rosebud, and of the battle, as I have been able to collect them up to the present time. On the 22d they marched 12 miles; on the 23d they marched 35 miles; on the 24th they marched from 5 a. m. till 8 p. m., or about 45 miles; they then rested for four hours. At 12 they started again and proceeded 10 miles. They were then about 23 miles from the village. They reached the village about 2 p. m. on the 25th. They had made a march of 78 miles in a day and a half, and, Captain Benteen tells me, without a drop of water. At some distance from the village, Custer made his disposition of the regiment. He ordered Benteen, with three companies, to move to the left and scour the country for Indians. He ordered Reno, with three companies, to advance parallel with his (Custer's) own command. When the village was sighted, he ordered Reno to charge with his three companies, telling him that he would be supported. Reno crossed the river at the point A, (see sketch herewith,) and moved down the woods at C without encountering much opposition. On reaching this latter point, the men were dismounted and deployed as skirmishers on the line indicated on the sketch. The Indians immediately swarmed around them, and Reno, finding that they were getting in his rear in large numbers, remounted his command and charged through them in retreat to the bluffs on the opposite side of the river. There were Indians on all sides of them, and Lieutenant McIntosh and several enlisted men were actually pulled from their horses and butchered. The command, with some loss, including Lieutenant Hodgson, reached the bluffs, and, being joined by Benteen and his command, they succeeded in keeping the Indians off. Benteen had received an order from Custer to hurry up, as the village had been struck, and in moving up he saw Reno's retreat, and joined him on the bluffs as quickly as possible. The Indians were all around them, and kept up an inces-


CUSTER'S BATTLE-FIELD
(June 25th 1876)
Surveyed and drawn under the personal supervision
of
LIEUT. EDWARD MAGUIRE
Corps of Engineers U.S.A.
by
Sergeant Charles Becker
Co. "D" Battalion of Engineers
Note:- The figures on the map are those of the stakes driven into the ground to mark the graves.
1 Capt. M.W. Keogh 7th Cav
2
3 Lieut. J. Calhoun, 7th Cav.
4 Lieut. J.J. Crittenden 20th Inf.
5 Lt. Col. G.A. Custer 7th Cav.
6 Capt. T.W. Custer 7th Cav.
7 Capt. G.W. Yates 7th Cav.
8 Lieut. W. Van W. Reily 7th Cav.
9 Lieut. A.E. Smith 7th Cav.
10 Lieut. W.W. Cooke 7th Cav.
11 Mr. W.B. Custer.
12 Mr. Reed
Scale of Miles.
0
½
1
2
Little Big Horn R.
Indian village
Reno's command
Lt. Hodgson Killed
Lt. McIntosh Killed
Reno's skirmish line

sant fire of unerring accuracy. In the mean time, Custer had gone down stream and attempted to make a crossing at the point B, but was met by an overpowering force, and the troops retreated to the hills in rear in order to procure a more defensible position. From the position of the dead bodies on the field, I conclude that they retreated on the two lines marked on the sketch to concentrate at E, which was the highest point of the ground. At the hill D a stand was undoubtedly made by the company under command of Lieutenant Calhoun to protect the men passing up to E. Lieutenants Calhoun and Crittenden were killed on this hill. Captain Keogh was killed about half-way up the slope to E. The column which retreated along the line B H E must have been dismounted, and, fighting along the whole distance, a portion of its men, taking to the ravine H for shelter, must have been surrounded by the Indians. There were twenty-eight bodies found in this ravine. From H to E stretched a line of dead men with skirmish intervals. The crest E was literally covered with dead officers and men. Here we found General Custer and his brother, Captain Custer, Captain Yates, Lieutenant Smith, Lieutenant Cook, and Lieutenant Riley. The Indians must have been present in overwhelming numbers, for this part of the fight did not, from all accounts, last over two or three hours.

As night came on, the attack on Reno ceased, and the troops were enabled to intrench. The attack was renewed early on the morning of the 26th, and continued until late in the afternoon, when the Indians, seeing Gibbon's column advancing in the distance left Reno, and, packing up their village, moved off toward the Big Horn Mountains. The number of Indians is estimated to have been fully 3,000 warriors, and they marched off with all the precision of movement and regularity of formation of the best-drilled soldiers. The officers tell me that they (the Indians) fought with the utmost bravery and coolness, and that they were well drilled and disciplined. Volleys were fired by them at the commands "Ready! Aim!! Fire!!!"

The casualties of the Seventh Cavalry are as follows:

Killed.—Lieut. Col. G. A. Custer, Seventh Cavalry; Capt. M. W. Keogh, Seventh Cavalry; Capt. G. W. Yates, Seventh Cavalry; Capt. T. W. Custer, Seventh Cavalry; Lieut. W. W. Cook, Seventh Cavalry; Lieut. A. E. Smith, Seventh Cavalry; Lieut. D. McIntosh, Seventh Cavalry; Lieut. J. Calhoun, Seventh Cavalry; Lieut. J. E. Porter, Seventh Cavalry; Lieut. B. H. Hodgson, Seventh Cavalry; Lieut. H. M. Harrington, Seventh Cavalry; Lieut. J. C. Sturgis, Seventh Cavalry; Lieut. W. V. W. Riley, Seventh Cavalry; Asst. Surg. G. E. Lord; Act. Asst. Surg. DeWolf; Lieut. J. J. Crittenden, Twentieth Infantry—16 officers; 252 enlisted men; 9 civilian employés: 277 killed; 59 wounded. The number of Indians killed and wounded is not known.

We remained two days on the field to bury the dead and burn the material left by the Indians, and then returned to the boat with the wounded, who have all been sent to Fort Lincoln. We are here waiting in camp for instructions.

There are some conclusions which force themselves upon the mind as indubitable. They are as follows:

1st. The number of Indians was underestimated at the outset of the campaign.

2d. The courage, skill, and, in short, the general fighting ability of the Indians has heretofore been underestimated and scoffed at. It has been forgotten that the Indian traders, by furnishing the Indians with the best breech-loading arms, and all the ammunition they desire, have

totally changed the problem of Indian warfare. Sitting Bull has displayed the best of generalship in this campaign. He has kept his troops well in hand, and, moving on interior lines, he has beaten us in detail.

3d. The Indians are the best irregular cavalry in the world, and are superior in horsemanship and marksmanship to our soldiers, besides being better armed. Our regiments of cavalry are composed of men about three-fourths of whom are recruits, who have never fought with Indians. They are never drilled at firing on horseback, and the consequence is that the horses are as unused to fighting as the men themselves, and become unruly in action.

4th. The carbine has not a sufficiently long effective range, and, considering it simply as a weapon for close encounters, it has not the advantages of a magazine-gun.

The trail has been kept, and observations with the sextant have been made whenever practicable.

Very respectfully, your obedient servant,

EDW. MAGUIRE,
First Lieutenant Corps of Engineers,
Chief Engineer, Department of Dakota.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

APPENDIX P P.

ANNUAL REPORT OF CAPTAIN W. S. STANTON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF THE PLATTE.

HEADQUARTERS DEPARTMENT OF THE PLATTE,
ENGINEER OFFICE,
Omaha, Neb., September 23, 1876.

GENERAL: I have the honor to submit the following annual report of surveys and reconnaissances in the Department of the Platte for the fiscal year ending June 30, 1876:

Congress having made no appropriation for surveys and reconnaissances in military divisions and departments, my assistance has been limited to the services of one draughtsman. Work has been, therefore, restricted necessarily in the field to minor surveys, and in the office to the preparation of maps of those surveys, and to work of a routine character incidental to the headquarters of a department, such as the preparation of various plots and tracings, the mounting and preparation of maps for issue, the issue of maps and drawing-materials to officers and posts, and the compilation of the very meager and imperfect information elicited in connection with the movements of troops.

Because of the utter want of the necessary means, no progress of importance has been made with the large amount of work obviously and urgently needed to advance the maps of the department from their

present incomplete, imperfect, and neglected state to one wherein they would embrace all the latest information, and much more fully meet the demands of the service.

INSPECTION OF WROUGHT-IRON BRIDGE AT FORT LARAMIE.

I was charged by the department commander with the preparation of the plans of the foundation of the wrought-iron bridge built by contract, under the Quartermaster's Department, over the North Platte River, near Fort Laramie, and with the inspection of both its sub- and superstructure. This bridge was described in my last annual report.

The substratum forming the bed of the foundation, supposed, on sounding to it with an iron rod through the overlying stratum of sand, to be rock, proved on excavating to it to be compact and level stratum of hard-pan and bowlders. The foot-plates of the eight struts forming each pier and abutment were bolted to a carefully-arranged grillage-foundation resting on this stratum, and placed well below the low-water line. To increase the deficient mass of these piers, this grillage was surmounted by a crib-work, and further security given by placing an ample and substantial crib with ice-breaker above each pier, both the crib-work surmounting the grillage and the crib with ice-breaker being filled with stones. The bridge was inspected on its completion, in December last. It was tested as fully as the means available would permit by loading each span successively with a train of Army wagons loaded with stone, and weighing 98,200 pounds. The guaranteed working-load of the bridge, with a factor of safety of 4, was 100 pounds per square foot of platform, being 1,200 pounds per linear foot of bridge. The deflection of the two 125-foot spans was seven-tenths and nine-tenths of an inch with the above testing-load of 785 pounds per linear foot. The deflection of the most heavily-loaded truss in the 150-foot span was 2 inches, the load on that truss being 74,000 pounds, or at the rate of 996 per linear foot of bridge.

The inspection exposed several palpable defects, attributable to the culpable carelessness of the contractors in intrusting the erection of the bridge to an incompetent superintendent, although long employed by them in that capacity.

Having been accepted by the Government, on the recommendation of a board of officers, after the correction by the contractors of the more serious defects, the bridge has since sustained the large amount of travel between Cheyenne and the Black Hills, and was of great utility in May last in the passage of the larger column of the Big Horn and Yellowstone expedition, obviating the tedious process of crossing it by a trail-bridge at Fort Fetterman.

RECONNAISSANCE OF ROUTE FOR INDIAN SUPPLIES FROM CHEYENNE, WYOMING, TO RED CLOUD AGENCY, NEBRASKA.

Pursuant to a request made by the Department of the Interior on the War Department for the measurement of the route by which Indian supplies were transported from Cheyenne, Wyoming, to Red Cloud agency, Nebraska, a careful reconnaissance of that route was made by me with odometers and prismatic compass in October last. Three odometers were used; one on each fore-wheel of an ambulance, and the third on the fore-wheel of a light army-wagon. The number of revolu-

tions per mile was carefully determined and checked by accurately measuring with a steel chain occasionally a mile of the road. These measurements with the chain were made especially to embrace every variety of road, as regarded both quality and condition of soil and the accidents of the ground.

The direct road from Cheyenne to Red Cloud agency branches into two at a point about 8 miles southwest of the North Platte River, which continue separate to the agency. The reconnaissance embraced both branches.

As determined by the odometers, the distance between Cheyenne and the agency by the southern or freight route proper is 152.65 miles, and by the northern or mail route, 145$\frac{4}{1000}$. The length of this route by the northern branch was measured during the agitation following the discovery of gold in the Black Hills of Dakota, in the autumn of 1874, for the board of commissioners of Laramie County, Wyoming, with a surveyor's chain, by the deputy county surveyor. It appears from a certified copy (secured from the county clerk for the file of this office) of his report to the board that the distance by his measurement is 145 miles 25 chains. It will thus be seen that the result by chain-measurement and that by the odometers differ about one-quarter ($\frac{246}{1000}$) of a mile. It is necessary to transport freight over the southern and longer of these two branches because of 3 miles of very deep sand on the mail-branch, among the sand-hills bordering the valley of the North Platte on the northeast, where the road is excessively heavy and almost impassable for heavily-loaded teams.

On this route by the northern branch there are 28 miles, and by the freight-branch 46 miles of road, which are sandy and more or less heavy. There are no means on either branch of crossing the North Platte River during high water, and the fords at low water are changeable and difficult. This route is now unimportant and a disadvantageous one. The route from the Union Pacific Railroad, at Sidney, direct to Camp Robinson, is 102 miles shorter by railroad, and 56 miles shorter by wagon-road for freight sent from the east to Camps Robinson and Sheridan and Red Cloud and Spotted Tail agencies. On the Sidney route there is a substantial wooden bridge, built last spring by private enterprise; the road is less sandy and better, and the route is equally as good as regards water, grass, and wood. On both routes there is little wood, and it is necessary to carry it two days' march. The bridge is single track, of the king-post form of truss, and is supported by piles. It is built at a small island. The part over the main channel is 1,856 feet long, consisting of 58 spans of 32 feet each; that between the island and the nearest bank, containing three such spans, is 96 feet long.

RECONNAISSANCE WITH BIG HORN AND YELLOWSTONE EXPEDITION.

From the middle of May until the close of the fiscal year I was engaged on reconnaissance in connection with the Big Horn and Yellowstone expedition against hostile Sioux Indians in the region of Rosebud Creek and Tongue River.

The expedition was organized at Fort Fetterman from two columns of troops, which marched to that post from the Union Pacific Railroad, one column from Medicine Bow station by the summer route across the northern part of the Black Hills of Wyoming, direct to the fort where it crosses the North Platte by a trail-bridge; the other column from

Cheyenne to Fort Laramie, over the new bridge there, thence up the northeast bank of the river to the organizing camp, opposite Fort Fetterman.

The expedition comprised 15 companies of cavalry, 5 companies of infantry, and a train consisting of 105 wagons and 600 pack-mules. Commanded by General Crook in person, the expedition commenced its march northward from Fort Fetterman, taking the old Montana road via the old Forts Reno, Phil. Kearny, and C. F. Smith, at 1.30 p. m., May 29. It advanced northwest by west 10.3 miles to its first camp on Sage Creek, a stream which skirts the road for several miles, is destitute of wood, and varies in character between a dry, sandy, narrow bed and a grassy swale with pools of brackish water.

The country is rolling and covered with thin grass, with sage-brush and cactus predominating. Excepting the first 3 or 4 miles from the North Platte, where it is sandy and rather heavy, the road is good.

May 30.—Marched 8 miles in the same general direction as yesterday, and over a country of the same character; then until reaching camp nearly north over a rolling country, the divide between the waters of the North Platte and the South Fork of the Cheyenne. About 3.5 miles before reaching camp, the road descended rather abruptly to Brown Springs, a small stream with good grass, no wood, and brackish water running sluggishly or standing in pools. Camped on the first of the branches of the Cheyenne; distance marched, 19.9 miles; grass generally good, mingled with some sage.

May 31.—Then marched cross the region of the headwaters of the Cheyenne; crossing two intermediate tributaries to that river, the column camped on a fourth, last night's camp being on the first. These four branches are alike, insomuch as they are all characterized by wide, sandy beds and very little water. The first of them affords the first wood on the road north of the Platte; its bottom, which is about 150 yards wide, and bounded by steep banks 50 to 60 feet high, containing scattering cottonwood-trees; its bed is about 50 feet wide, and has a little water, either running on the surface or sunk in the sand. The second branch, about 12.5 miles from the first, has a bed about 200 feet wide, a little water alternately running on the surface and sinking, and no wood. The third branch, about 5.75 miles from the second, has steep banks, 40 or 50 feet high, a bed about 300 feet wide, with a single pool of water in the vicinity of the road, and contains scattering cottonwood-trees. The fourth branch, about 2.5 miles from the third, has a bed about 250 feet wide, a stream of clear brackish water about 5 feet wide and 3 or 4 inches deep, and no wood. The country is rolling and broken, the road crossing several narrow ravines, one with frequent pools of brackish water. The crossing of one or two of these ravines is miry and bad; and of the first and third branches of the Cheyenne, steep and very sandy, and heavy for loaded teams. The road is elsewhere generally good, but rather hilly and crooked. Its general course continued nearly due north, a little west, for 7 miles; then west-northwest about 4.5 miles; and then north-northwest to camp. Distance marched, 20.75 miles. Bunch-grass thin to fair, mingled with considerable sage. The region of this march is that traversed October 20 and 21, 1859, by Mr. J. H. Snowden, of Colonel Raynolde's expedition. This day, from the divide between the first and second branches of the Cheyenne, on our right and left front, respectively, were first seen Pumpkin Buttes and the heavily snow-clad summits of the Big Horn Mountains the latter henceforth the bold and dominant feature in the land-

scape. Laramie Peak was last seen from the divide between the second and third branches.

June 1.—Broke camp in a snow-storm and marched four or five hours in driving snow and rain. General course nearly north 3 miles; next northwest 15 miles; thence north half west to camp on the Dry Fork of Powder River.

The country for the first 10 miles was rolling or rolling and broken, forming the divide between the waters of the Cheyenne and Powder Rivers. Then it became quite broken, the road soon ascending to the crest of a long, narrow ridge, separating the valley of the Dry Fork on the left from a very broken country extending to Pumpkin Buttes on the right, and characterized by almost innumerable small ravines between low, rounded ridges, having a washed and very barren aspect. Beyond the valley on the left was seen a range of hills apparently pine-clad. The road descended rather abruptly from the ridge to the Dry Fork. Distance marched 21.4 miles; road crooked and hilly, and in places rather heavy from being imperfectly beaten; bunch-grass fair to good, mingled with scattering sage.

June 2.—First for 13.3 miles the road lay along the bottom of the Dry Fork, frequently crossing the dry bed of that stream; course, first 3 miles north by west; next 10.3 miles northwest by west; then the road, leaving the bottom, ascends the bluffs which bound it on the right bank and leads north-northwest over a broken, barren, and utterly worthless country 4 miles to old Fort Reno, on the left bank of Powder River. The column crossed and camped on the left bank in the bottom at the ford, and between it and the old fort. Distance marched 17.3 miles; road good.

The Dry Fork of Powder River has a bottom 150 to 250 yards wide, well timbered with groves of cottonwood-trees, and bounded by abrupt bluffs occasionally vertical, and exposing a stratum 18 inches thick of lignite, underlying one of disintegrating slate about 3 feet thick.

The bed of the stream is about 50 feet wide, occasionally miry, but mostly sandy, and everywhere dry except a few pools of brackish water at last night's camp, and one passed on the march to-day. In descending it, the trees increase in number and size, many being 1 foot to 16 inches in diameter; the grass is generally poor and mingled with cactus and sage.

Powder River measured 112 feet wide, 2½ feet deep; has a bed of sandy mud, muddy alkaline water, a rather swift current, and gentle banks, and a good ford at the fort. Its bottom is about a mile wide, and is well timbered with cottonwood. The confluence of the Dry Fork is about 2½ miles above the fort, at which point there is quite a cottonwood forest.

In the bluff, about a mile and a half from the fort, on the opposite bank, coal of an inferior quality, impregnated with sulphur, is said to have been quarried for use to a limited extent by the garrison.

Fort Reno is on a plateau about one-third of a mile from the ford and 40 feet above the river. The ruins consist of the walls of an adobe house, the large chimneys of the barracks and quarters, among which are scattered *débris* of stoves, iron bedsteads, &c., and rows of posts marking the site of the corral. They are almost as conspicuously seen on ascending the divide in obliquing from the Dry Fork to the river as could have been the fort before its abandonment. Distance from Fort Fetterman, 89.7 miles. Elevation, (approximate,) 4,250 feet.

June 3.—Marched over a rolling country to Crazy Woman's Fork of

Powder River, rapidly approaching the Big Horn Mountains, the general course being northwest the first 12 miles, and afterward northwest by north. The road constantly bearing more and more to the north keeps the higher ground and describes a large curve. It might be considerably shortened by following the valley lying along the chord to the east. Distance, 25.5 miles; road good, but occasionally rather hilly; grass thin and poor throughout the march, and mingled with sage, cactus, and moss. Crazy Woman's Fork is a stream of good water, about 45 feet wide and 2 feet deep, with a muddy bed and rather high, steep banks.

June 4.—Still rapidly near the Big Horn Mountains the column advanced over a rolling and somewhat broken and hilly country northwest half north 15 miles; next 3.4 miles north by east half east toward "the reddish broken hills" mentioned as immediately upon his left by Colonel Raynolds in his journal, September 19, 1859; then north by west to camp on Clear Fork of Powder River. Distance traveled, 22.4 miles; road rather hilly, but generally good otherwise; grass better than yesterday, but still poor, and occasionally mingled with cactus and sage.

The Clear Fork is a fine stream about 40 feet wide, with clear, pure, cold water, 2½ feet deep, running rapidly over a bed of bowlders. It is fringed with willows, and has a very few trees. It appears to flow directly from the mountains, which are now near enough to be boldly outlined against the sky and to form a striking and beautiful western landscape.

This stream in its mountain-like character is, in all the region north from Fort Fetterman, the first feature producing an agreeable impression, intensified by contrast with the prevalently meager and alkaline streams hitherto.

June 5.—Moved over a very rolling and hilly country in a general direction northwest by north, 15.5 miles to old Fort Phil. Kearny, and camped on Little Piney Creek. Two and one-half miles from the Clear Fork we crossed a fine stream called Rock Creek, about 30 feet wide, with clear, good water, about 15 inches deep, a brisk current, and gravelly bed.

About 5 miles south of the fort, and a mile and a half east of the road, is Lake De Smet, an apparently shallow pond of brackish water, perhaps 2 miles long by ½ a mile wide, surrounded by hills and land broken by difficult ravines. At its shore it is disappointing and much less attractive than the blue sheet of water affording so refreshing a relief to the eye when first seen in the distance.

Rock Creek must be the stream down which Colonel Raynolds marched just before going into camp September 19; his route and march of that day being almost identical with ours to-day, and his route of September 20, obliquely crossing ours of yesterday; thence south to the Platte, he kept farther west and close to the mountains.

The site of Fort Phil. Kearny is the narrow valley of Little and Big Piney Creeks, between steep and high hills, commanding it. It is a small plateau about 40 feet above the Little Piney, immediately on its left (north) bank, between the two streams, and about half a mile above their confluence. Southeast of it about 1,300 yards, and raising 375 feet above it, (by the aneroid,) is "Picket Hill," a pinnacle surmounted by the remains of a slight breastwork, where was posted a picket to signal to the garrison the movements of Indians. On the slope at the northern base of this hill is the post-cemetery, in which is a long trench, where

lie the remains of those who fell in the massacre. Its fence and the brick monument are becoming somewhat dilapidated.

The ruins of the fort, consisting of the charred posts of the stockade, the prostrate flag-staff, foundation of the houses, and *débris* of stoves, iron bedsteads, &c., conspicuously mark its site. It is distant from Fort Reno 63.6 miles, from Fort Fetterman 153.3 miles, and its approximate elevation above the sea is 4,800 feet.

The Little Piney is a stream ot good water, about 15 feet wide, 15 inches deep, fringed with willows, and obstructed by beaver-dams. On its right bank, about a quarter of a mile above the post, an officer, stationed at the fort in 1867, informs me coal of fair quality was obtained for the blacksmith, and was burned in their quarters by a few of the officers.

The Big Piney is a very fine, torrent-like stream of clear, pure, cold water, about 70 feet wide, 2½ feet deep, with a very strong, rapid current, and bed of bowlders. It is fringed with tall willows, and on its north (left) bank is a thick grove of willows and cottonwood. On its banks, about 5 miles above the crossing and the fort, in the foot-hills of the mountains, is an abundance of good pine-timber.

June 6.—Leading across the fork between the creeks, crossing the Big Piney, and winding among steep and high hills, the road reaches, 2.7 miles north-northwest of the fort, the sharp crest of the very narrow divide separating the waters of Powder and Tongue Rivers. Crossing in the next half mile a narrow valley, it reaches the head of a long, narrow ridge, the sloping crest of which it follows north by west one mile and a half till it sinks into a wide, meadow-like valley, with tall and excellent grass, through which winds the Pino, a brook about 6 feet wide. The crest of this ridge, barely wider than the road upon it, is the field of the massacre by the Sioux Indians of Colonel Fetterman and his entire command of 91 officers and men, December 21, 1866, the bodies of the slain having been found in and on the sides of the road from the foot of the ridge at the meadow along nearly the entire half to its head. Near the latter point, at the west edge of the road, is a group of three or four rocks, around which were heaped many bodies, supposed to be ot those longest surviving in the desperate struggle to reach the fort.

Leading north-northwest 2 miles across the valley and the Pino, the road, by a very winding and devious course, generally north, among high and steep, rounded hills, reaches in 4 miles Hay Creek, crossing which it continues north-northwest down its right bank, on which the ninth camp of the command was pitched. Distance marched, 17.75 miles. Road good, excepting the hills and one or two rather miry crossings. The old Fort C. F. Smith road, plain and unmistakable from Fort Fetterman to the valley of the Pino at the foot of "Massacre Hill," is thenceforth nearly obliterated and often barely traceable in the taller grass of this region.

June 6.—The column continued down the right bank of Hay Creek 5.5 miles; crossed and advanced down its left bank 2.75 miles to Prairie Dog Creek; then down the left bank of the latter stream to its mouth on Tongue River, on the right (south) bank of which, in the fork, camp No. 10 was pitched. Distance marched, 16.8 miles; general course throughout the day almost due north.

The crossing of Hay Creek and of two ravines, where Prairie Dog Creek forced the column out of the bottom upon the bluffs, required a little cutting and filling, delaying the train somewhat; otherwise the road was fair for a new one, the column having left the old Fort

C. F. Smith road on its left flank above the lower crossing of Hay Creek.

Hay Creek is a stream of good water, about 8 feet wide, 1 foot deep, with a sluggish current, a bed of mud and gravel, and a narrow bottom, jungle-like for several miles along its upper part, with a thick growth of willows, bushes, and stunted elm-trees. On the right bank, its valley is bounded by barren, reddish-brown hills, the grass being rather thin and mingled with sage, while on its left bank the hills are lower and rounded and the grass excellent.

Prairie Dog Creek is about 10 feet wide, 1 foot deep, with a bed of mud and gravel, and is much obstructed with beaver-dams. Its valley contains in places excellent grass, in others thick sage. On the east are low, barren hills, rising in the distance to the low, reddish-brown Wolf Mountains. Near its mouth its valley becomes very narrow, being there bounded on the west by the rough, broken, and stony country between it, the valley of Goose Creek, and Tongue River. A few buffalo were first seen yesterday and to day and two or three killed.

June 8.—In camp, the command taking its first rest after an uninterrupted march of 188 miles from Fort Fetterman. The train is formed into a corral for the animals in the river-bottom amid a grove of large cottonwood-trees, while the troops are encamped on a bench back of and below it. Tongue River measured 160 feet wide and is about 3 feet deep. It has here very broken and irregular banks, and is very crooked.

June 9.—In camp. Cloudy, preventing observations. Indians were first seen to-day. At retreat almost simultaneously with the alarm from the picket near the mouth of Prairie Dog Creek on its opposite bank, a scattering fire was opened on the camp by a party of Indians from the crest of the very high, rocky, and nearly vertical bluff forming the opposite river-bank. They continued firing about twenty minutes, until a force of cavalry saddled, forded the river, and drove them away. A very few animals were wounded in the camp, but fortunately no men.

June 10.—In camp. Observed the sun morning and afternoon.

June 11.—The column broke camp and returned by its trail of the 7th up the west bank of Prairie Dog and Hay Creeks, 11.3 miles, to its lower crossing of the latter stream; then, without recrossing it, farther ascended the valley south-southwest 2.75 miles; next by a devious route following a general course west by south, passing over a narrow range of rounded, grass-covered hills, and crossing on their summit the old Fort C. F. Smith road, it reached Goose Creek at the mouth of its south branch, crossed to the west (left) bank of this branch, and pitched camp No. 11 in the fork on it and the main stream. The last hour's march was made and camp pitched in a cold, pelting rain. Distance marched, 17.6 miles; route good; length of new road reconnoitered, 6.3 miles. This is the place appointed for the column to await the arrival of the force of Crow Indian scouts, and is an admirably selected position. It has good water, grass and wood in abundance for the camp, and is a natural strategical point, being approximately the center of an arc along the radii of which lie the Little Big Horn, the Rosebud, the Tongue, and the Clear Fork of Powder River, (branch formed by the Little and Big Piney.) From it, in a single day's march, a light column can put itself in motion down the valley of either of those streams, which are natural lines of operation, passing entirely through, and dividing into not very unequal parts the whole region which is the great resort of the hostile Sioux. Moreover, it is on the direct line of supply from Fort Fetterman, is in easy communication by the Fort C. F. Smith road with

the valley of the Big Horn River below the cañon in the Big Horn Mountains, and, on the melting of the snow in the mountains, by Goose Creek Pass, practicable for a pack-train, with the valley of that river west of that range.

The guide, Frank Grurard, says there are three principal passes over the Big Horn Mountains; the best enters along the left bank of Rotten Grass Creek, and leads north of west; the second in order of practicability enters about 3 miles north of the North Fork of Tongue River and leads a little south of west; the other enters about 2 miles north of Goose Creek and leads north of west. He says the two former could, without great labor, be made practicable for wagons, but that the Goose Creek Pass would be practicable only for pack-animals.

June 12.—In camp. Observed the sun morning and afternoon. Goose Creek above the south branch is about 50 feet wide and 2 feet deep; its banks are low, and fringed in places with willows, but without trees. The south branch has about the same width, is about 18 inches deep, and has a sandy bed; its banks are low and fringed with willows and groves of cottonwood-trees. Both streams have clear, cold, and excellent water and a rapid current.

June 13.—In camp. Observed the sun morning and afternoon.

June 14.—In camp. The barometer indicates an approximate altitude of 3,680 feet. The three guides who left the column at old Fort Reno on the 2d on their perilous journey of 200 miles to the Crow camp, beyond the Yellowstone, to secure the scouts, returned this afternoon with 160 Crow Indians. A few hours later, 67 Snake Indians also joined the column.

June 15.—In camp, preparing for the advance to-morrow. Mules are being selected from the pack-train, and equipped for mounting the infantry; rations drawn, &c.

June 16.—At 6 a. m., General Crook, with all the cavalry, and the infantry mounted on mules, headed for the Rosebud. The column is as light as possible, and is admirably equipped for celerity of movement. Each officer and man is limited to four days' rations, his overcoat, and one single blanket; the men carrying each 100 rounds of ammunition. The odometer-cart is the only vehicle in the column. The column crossed at camp to the left (west) bank of Goose Creek, and marched in a general course north-northwest 7 miles, the route lying for the first 4 miles in the valley of the creek, and then on higher, broken, and rolling ground; next moving northeast by north 4.25 miles, it crossed the deep and narrow valley of Tongue River, and climbed to the crest of the high ridge on its north side, gravelly and broken, with patches of sage and scattering pine-timber. Tongue River was crossed about 1 mile above the mouth of Goose Creek, and is there about 100 feet wide, 2½ feet deep, with a strong current, low banks, and a good ford. Between the camp and the river the grass varies from good bottom and bunch grass in the valley of Goose Creek to fair bunch-grass on the intervening higher ground, and is throughout mingled with occasional patches of sage. From the crest of the ridge bordering the river-valley, the route lay nearly north about 7.5 miles, through an excessively broken, rough, and stony country, to the narrow valley of a small stream draining apparently into Tongue River, but dry excepting in pools.

The column next ascended this valley about 6.5 miles to its head, and reached the summit of the divide between the waters of the Tongue and the Rosebud, meeting a small herd of buffalo.

From this summit the course lay about north-northwest 8 miles, over

a region of high, rounded, and steep hills, with small miry streams at their bases, and abounding with excellent grass, to the Rosebud, on both banks of which headquarters and the cavalry bivouacked at 7.20 p. m., the infantry arriving somewhat later.

June 17.—The column marched at 6.15 a. m., and moved down the valley of the Rosebud, closely following its left bank, in a general northeast direction, until 7.15, when it was halted to await information from the Indian scouts, who reported the Sioux in the vicinity. In about one hour, the Sioux appeared in force in the broken country immediately north of the Rosebud Valley, and an engagement at once ensued, continuing about four hours, and resulting in completely routing the enemy, undoubtedly with quite severe loss, the troops following some distance, and bivouacking at night unmolested in the valley of the creek where they halted just before the fight commenced. The field of the engagement is one of valleys and steep, rounded hills, merging into deep ravines, and steep, stony, and somewhat rocky ridges, which, in descending along the valley of the creek, or in advancing northward from it, at once become deeper, steeper, more broken, and precipitous, and sprinkled with pine-timber. It is a region very unfavorable for a pursuit and very favorable for concealing the position and strength of a force awaiting attack.

The Rosebud in this vicinity is a stream of good water, 4 or 5 feet wide, an inch or two deep, with a slight current, a miry bed, with rather steep, muddy banks, and lying in a narrow bottom containing a few cottonwood-trees and a thick growth of brushes and willows.

June 18.—The column at 6.30 a. m. began its march to camp, and moved up the left bank of the Rosebud to its source in a direction nearly southwest by west about 7 miles, reaching the narrow summit of a very high ridge dividing its waters from the Tongue.

The Rosebud is formed on the northeast slope of this ridge from several small brooks, and has a rapid descent for 2 or 3 miles through a narrow, grassy ravine, which then widens to a valley from 100 to 200 yards across, between the bivouacs of the 16th and 17th, being bounded on the left bank by high, rounded, grassy hills, and on the right by higher, steeper, and rather rocky bluffs; the distant ranges on either bank being sprinkled with pine-timber.

This abruptly elevated region in which the Rosebud rises is one of marked topographical characteristics. From the summit of its culminating ridge, the Big Horn range is in clear view from the bald promontory where it is pierced by the Big Horn River to Cloud Peak; extending far to the north lies the valley of the Little Big Horn, and to the northeast the valley of the Tongue, with the Wolf Mountains beyond. It is much to be regretted that the position of this point could not have been determined.

The route was next very devious, on a course about south by west, continuing in this elevated region among high and steep, grass-covered hills and deep ravines, occasionally broken and stony. Bivouacked at 2 p. m. on a small stream of good water, thickly fringed with bushes and a few trees, between towering hills, and flowing east-southeast, probably into the Tongue. Distance marched about 20 miles.

June 19.—Marched at 5.30 a. m. Route devious, on a course about south by east, through the same elevated region of grassy hills and ravines, about 3.5 miles, to its southern limit. Next, after a very abrupt and steep descent, continued the same south by east course about 5 miles, over a barren and somewhat broken country, with gravelly soil, little or no grass, thick sage, and some cactus, to Tongue River; forded, and,

moving thereafter on a general southeast by east course, crossed first about 2.5 miles of the same barren, sage-covered region, next about 3 miles of comparatively level and better country, with better grass, to the old Fort C. F. Smith road, which there lies along the northeast (left) bank of Beaver Creek, a stream about 6 or 8 feet wide and 18 inches deep, thickly fringed with bushes, with muddy banks, miry bed, obstructed by beaver-dams, and bad to cross; crossing the old road and the creek, the column kept its southeast by east course over a rolling and hilly country, about 4 miles, to the wagon-train on the south (right) bank of Goose Creek, about 3 miles above the fork, it having moved there with camp on the 16th. The column, wagon-train, and pack-train crossed the fork about 4 miles to the left bank of the south branch of Goose Creek, about 5 miles above its mouth, and camped.

June 20.—Entire command marched south-southwest 7 miles, up the left bank of the south branch of Goose Creek, and pitched Camp Cloud Peak on it at the crossing of Bridger's cut-off branch of the Fort C. F. Smith road.

June 21.—The entire wagon-train of the command, with the ambulances containing the wounded, began at 5 a. m. its return march to Fort Fetterman for supplies. It moved over a country of high, steep, grass-covered hills and grassy ravines, occasionally with a small, miry stream, by Bridger's cut-off, southeast 10.5 miles, to its junction with the main Fort Smith road at the foot of Massacre Hill, 4.7 miles north of Fort Phil. Kearny, thence following the route by which the command advanced, and closing the reconnaissance.

Describing generally the country seen on the reconnaissance, the region from Fort Fetterman to old Fort Phil. Kearny is rolling and sometimes broken, the soil sandy, and the grass, although occasionally fair, generally thin and poor; all the water south of Crazy Woman's Fork to the Platte is alkaline, and south of Powder River it is very scarce. This region is barren and uninviting in aspect, and almost, if not entirely, worthless. Although during the advance of the column, about the 1st of June, the grazing was tolerable or fair, on the return of the train the thin grass was so short and dried up that it afforded very scant subsistence for the animals.

Powder River had fallen considerably, and its water had become so strongly alkaline that it increased instead of allaying the thirst. Between it and the Platte, a distance of about 90 miles, not a drop of running water was found; the two branches of the Cheyenne, in which a little was running when we went north had dried up, and their beds in places were covered with a white alkaline deposit. Water for the 600 or 700 animals was found at the usual camping-places in pools and holes.

From Fort Phil. Kearny or Rock Creek north to Tongue River, and from the Big Horn Mountains east to Hay and Prairie Dog Creeks, is a hilly and rolling region, containing generally good grass and good water.

Finally, the elevated and excessively hilly region about the source of the Rosebud, extending from the abrupt, narrow, and barren ridge bordering the valley of the Tongue on the north, over to the field of the engagement of June 17, is covered with good grass and contains good water.

Excepting as specified along the streams, this whole country west of the foot of the Big Horn Mountains is destitute of timber.

Game is scarce; a few antelope were seen occasionally throughout the

march, and about the source of the Rosebud buffalo were seen in limited numbers.

The reconnaissance commenced at Medicine Bow, on the Union Pacific Railroad, May 21, with the march of the column which moved from that point, and embraced its route to Fort Fetterman. That route is now so frequented, and its region comparatively well known, that it is deemed superfluous to describe it.

The following is a statement of distances:

	Miles.	Miles.
From Fort Fetterman to—		
Camp No. 1, on Sage Creek	10.30	......
Camp No. 2, on south branch of South Cheyenne	19.88	30.18
Camp No. 3, on north branch of the South Cheyenne	20.77	50.95
Camp No. 4, on Dry Fork of Powder River	21.43	72.38
Camp No. 5, at old Fort Reno, (Powder River)	17.33	89.71
Camp No. 6, on Crazy Woman's Fork	25.70	115.41
Camp No. 7, on Clear Fork of Powder River	22.41	137.82
Camp No. 8, at old Fort Phil. Kearny	15.50	153.32
Camp No. 9, on Hay Creek	17.74	171.06
Camp No. 10, on Tongue River	16.81	187.87
Camp No. 11, on Goose Creek	17.61	205.48

Route reconnoitered from Medicine Bow to Fort Fetterman	85.00
Route reconnoitered from Fort Fetterman to Camp No. 11, on Goose Creek, (deducting route retraveled)	193.56
Route reconnoitered with odometers on march to the Rosebud	13.00
Route reconnoitered moving camp June 20	6.93
Route reconnoitered on return with train, (Bridger's cut-off)	10.63
Total length of reconnaissance with odometers	309.12
Total length of horseback reconnaissance on march to and from the Rosebud	61.25
Aggregate length of reconnaissance	370.37

The distance from Fort Fetterman, by Bridger's cut-off, direct to the camp (Cloud Peak) of June 21, on south branch of Goose Creek, is 168.64 miles.

In making the reconnaissance, I was assisted by the following persons employed in this office, viz: Mr. R. F. Koehneman, civilian, draughtsman and topographer; Private Henry Kehl, general service, clerk; Private Stephen Bowes, Twenty-third Infantry, messenger; and Private Charles Holtes, Fourth Infantry, detailed for the reconnaissance.

Mr. Koehneman recorded all the observations made with the compass, the odometers, and the aneroid, and carefully sketched the topography.

Private Kehl carried the chronometers and observed the aneroid on the march and the mercurial barometer in camp.

Private Holtes carried the cistern-barometers and read the odometers, and, being very ready with the pencil, made some very good sketches of scenery; the above three occupying the ambulance provided for the purpose, to each fore-wheel of which an odometer was attached.

Private Bowes was orderly, and, having served as a soldier in the region of the reconnaissance, was very useful in accompanying me to elevations bordering the route, communicating with the markers, &c. The compass observations were taken by myself with a prismatic compass, the greater part of them recumbently, as necessitated by the prevailing wind.

The courses were taken with much care to conform closely to the route, averaged a little less than a mile long, and were denoted by two cavalrymen employed as markers, one upon whom to sight, and the other to relieve him and mark the point until my arrival, by which time the advance marker would again reach the new station. Numerous bear-

ings of all peaks and elevations of sufficient importance were taken, to locate them, by triangulation, and the aneroid was read at every course.

The sextant observations were made by myself, Mr. Koehneman being recorder. Although a part of the days were clear, unfortunately the nights were almost invariably cloudy, preventing astronomical work. When the camps permitted, the sun was observed for time; but the sextant-arc being too short, its meridian altitude could not be observed as a resort for latitude necessitated by the cloudy nights. Meteorological observations at hours corresponding to those of the Signal Service were taken during the reconnaissance at Forts Laramie and Fetterman by an enlisted man at each post detailed for that purpose. The few altitudes herein given have not been corrected by reference to the above stations and to the Signal Service at Cheyenne. A two-wheeled odometer-cart, for use with the cavalry column, was purchased by the Quartermaster's Department, and hastily made here, just before the reconnaissance commenced.

On the march to the Rosebud, its wheels proved very inferior, and one was so badly broken in the rough country immediately north of the Tongue that the cart had to be abandoned. Even had it not broken, its abandonment would soon have been necessary; for the country became so rough that it could not have kept up with a mounted column moving 35 or 40 miles a day.

The compass courses were continued with the same care as before, the indications of a watch being recorded instead of the readings of the odometer. A considerable part of the country was so rough, making the trail so full of short deviations, and so varying the rate of advance in the ascent and descent of steep slopes, that this reconnaissance from Goose Creek to the Rosebud was very unsatisfactory and of little value.

Fortunately, the abandonment of the cart was apprehended as a possible necessity, and no instruments were taken in it, as each man had too much to carry—his arms, ammunition, rations, blankets, &c.—to be charged with a sextant or chronometer. The draughtsman and meteorological observer remained in camp, charged with the care of the chronometers and instruments, and with meteorological observations; the other two men accompanied me.

As from the nature assumed by the campaign any further reconnaissance with the expedition would have been of the same unsatisfactory character as that from Goose Creek to the Rosebud, it was deemed much more advantageous to devote the remainder of the season and the services of the party to surveys much needed within the department. I therefore returned with it to Fort Fetterman at the close of the fiscal year, and at once commenced the following work, viz: The survey of the new wood reservation of Fort Fetterman; of the military reservations of Camps Robinson and Sheridan; the measurement and reconnaissances of all routes to and between the posts in the department; and the determination (with sextant) of the posts.

All the members of the party were faithful and reliable in the work intrusted to them, and Mr. Koehneman was especially painstaking and industrious in the unremitting work of recording the observations and noting the topography.

A map of the reconnaissance will be prepared as soon as practicable.

During the year, to the 30th of June, 594 miles of reconnaissance with odometers, and 61 miles of horseback reconnaissance, in the aggregate 655 miles, have been made in the department by myself, assisted by the persons employed in this office. No reconnaissances have been

received from officers, and there are no engineer soldiers in the department to aid in the work.

An improved topographical note-book has been prepared, which will contain printed instructions prescribing in detail the method of making a reconnaissance, and which will be issued for the use of officers as soon as there is any money for purchasing the necessary number of copies.

A few specially-instructed engineer soldiers are much needed to distribute about in the department and aid officers in this work. Strenuous efforts will then be made to secure from officers, through the use of this book, and the assistance of these soldiers, notes of marches sufficiently clear and accurate as regards *directions* and *distances* to be of use in filling in the map. Efforts to secure such notes have thus far been fruitless. During the year, 270 maps, and 60 printed reports of exploration and reconnaissances, with maps, have been issued.

It is desired to prosecute with the party from this office the following urgently-needed field-work during the field-season of 1877, viz:

To complete the measurement and reconnaissance of all the routes in the department; to make a reconnaissance of a route from Grand Island, Nebraska, on the Union Pacific Railroad, via Fort Hartsuff and Camp Sheridan, to the Black Hills; and also of the routes from the Black Hills to Camp Robinson and Fort Laramie; to reconnoiter a shorter route from the railroad to Fort Fetterman, and from the railroad to Camps Brown and Stambaugh; and to determine the position of many of the posts in the department, for which a zenith-telescope and astronomical transit are needed.

A part of this work was begun on returning from the expedition after the close of the fiscal year, and 505 miles of the routes surveyed, in addition to the three reservations, when it was stopped by the necessity of discharging my assistant for want of any appropriation whatever for his pay or for the work.

During the year, the procurement from the General Land-Office, through the Office of Chief of Engineers, of the maps and manuscript notes of all the State and territorial boundary surveys thus far made within the department, has been progressing, and they are now nearly all in this office. It now remains to procure copies of all the township-plats which have been surveyed in Nebraska, Wyoming, and Utah, when, with them, the boundary surveys, and the reconnaissances and determinations of posts proposed, an extensive revision and improvement in the maps of the department can be made. There being no money whatever applicable to it, this work is now entirely suspended, and must continue so until further appropriations.

The fiscal year just commenced is the third of my service in this Department with either money utterly inadequate to commence the work above described, or no money at all. At present, not even a pencil can be purchased for the office. For the work which has thus been accumulating for two or three years, an additional draughtsman will be needed in the office, who can also serve as an assistant in the field; after making 20 or 30 miles of reconnaissance through the day, one is too fatigued for astronomical work at night.

On completing their measurement and reconnaissance, it is intended to issue a printed itinerary of all the routes in the department, with descriptive notes.

I earnestly renew the recommendations made in my last annual report for the assignment of a detachment of engineer soldiers to this department, and an allotment of money sufficient for the purchase of the township-plats.

I also respectfully recommend that the money appropriated at the ensuing session of Congress for the fiscal year 1877–'78 may be made available as soon as appropriated, in order that work may be resumed as early as practicable.

I am indebted to General Comstock, Corps of Engineers, for telegraphic time-signals exchanged with the Lake-Survey observatory at Detroit, here, and at Fort Fetterman, for rating the chronometers and for determining the longitude of that fort.

Estimate of funds required for the fiscal year ending June 30, 1878.

For one draughtsman and assistant, at $150 per month	$1,800
For one draughtsman and assistant, at $125 per month	1,500
For purchase and repair of astronomical and reconnoitering instruments	2,200
For purchase of township plats of Nebraska, Wyoming, and Utah	4,000
For office and contingent expenses	500
Total	10,000

Very respectfully, your obedient servant,

W. S. STANTON,
Capt. of Engineers, U. S. A.,
Chief Engineer Department of the Platte.

The CHIEF OF ENGINEERS,
United States Army.

APPENDIX QQ.

ANNUAL REPORT OF LIEUTENANT E. H. RUFFNER, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF THE MISSOURI.

HEADQUARTERS DEPARTMENT OF THE MISSOURI,
OFFICE OF THE CHIEF ENGINEER,
Fort Leavenworth, Kans., July 12, 1876.

SIR: I have the honor to submit the following report of the operations of this office for the year ending June 30, 1876:

There having been no appropriation for surveys for military defenses, or for surveys and reconnaissances in military divisions and departments, during the last fiscal year, I have endeavored to arrange the records of the office in the best and most available shape as far as could be done with the assistance of one draughtsman. The engraving of the Indian Territory map was completed and the lithographic stones were sent to the printers for final work and the printing of the edition. This map was the result of three years' office labor, and the compilation of the authorities involved an amount of work known only to those who have done similar work. Since the commencement of the land-surveys in the Indian Territory, no suitable publication had appeared embodying their results. The attention attracted to the country by the earnest desire of many white men to settle thereon, because of their belief that the area embraced the best of land, increasing numbers of Indians removed and located on reservations, and, lastly, the Indian disturbances culminating in the campaign in the Indian Territory and Texas

of 1874–'75, made a large and accurate map a desideratum for military purposes, valuable for civil ends, and attractive to scientific students. The compilation, drawing, and engraving were done entirely in this office, and in the list of authorities published with the map will be found enough surveys executed by the military service to stamp the publication as essentially a military map.

To the end of securing the best attainable accuracy and the neatness of execution shown in the latest publications of the same character, the fullest details are given, and the utmost care was taken to give all, and nothing for which there was not authority in this office.

The size of the map, four large sheets, 22 by 18 inches, with the scale 1 : 500,000, nearly 8 miles to the inch, and the area covered over 125,000 square miles, combine to make this the most important work yet performed by this office.

I have been gratified at the comments of the public press on the "desire of the military authorities to render available as far as their limited means will allow the map material which is scattered through the various Government departments;" and my desire to improve the execution of maps of the western country, and particularize details, has also been appreciated.

In reply to a letter written Dr. A. Petermann, I have received the following:

REDACTION DER
"MITTHEILUNGEN AUS JUSTUS PERTHES' GEOGRAPHISCHER ANSTALT,"
Gotha, February 17, 1876.

MY DEAR SIR: I have the honor to acknowledge the receipt of yours of the 26th ultimo on the 12th instant, and of the map of the Indian Territory advised therein, this day. I beg to tender you my best thanks for your great kindness to send me this very valuable work, which forms a new era for the knowledge of that region.

It is a work of great merit, and accomplished within a short time, I think, and gives a new proof of the praiseworthy efforts of your military service in surveying and mapping the extensive regions of the United States. I am very happy to be favored by you with the communication of such valuable documents, and shall always feel most obliged to you for receiving similar ones at any future time.

I have the honor to be, my dear sir, your faithful and obliged servant,

A. PETERMANN.

First Lieut. E. H. RUFFNER, *Engineers.*

From authority as distinguished as Dr. Petermann, such a compliment is encouraging at a time when close economy at home has suspended all work not the most necessary.

A large edition of the military map of the Indian Territory was struck off, and both the Engineer Department and the Office of the Commissioner of Indian Affairs have been supplied. These maps have been largely distributed to the military service also.

The "Reconnaissance made in the Ute Country" in 1873 never having been completely mapped, the draughtsman continued the detail-sheets, and, on November 16, 1875, an atlas, containing 46 sheets, a "Sketch of the San Juan Mining Regions," and a "Sketch of the Philosophers' Mounts," were sent to the Office of the Chief of Engineers. This atlas completed the route of the expedition upon a scale of 1 : 50,000, and gave the smallest details recorded by the topographer.

The "Sketch of the Philosophers' Mounts" was a tracing from a map made by the draughtsman, Ado Hunnius, out of office-hours, and was more elaborate and finished than I have been able to expect from him in the regular course of work where one thing has followed another in rapid succession. The "sketch" is perhaps the handsomest specimen of topographical drawing ever executed in this office. Photographic

copies were made of the "Atlas of detail-sheets," and placed on file in the Engineer Department in Washington.

A report was made to the assistant adjutant-general, Department of the Missouri, on January 26, 1876, on "Communications between Northern New Mexico and Southern Colorado." This report was accompanied by a map on a scale of 1 : 1,000,000 of the region in question. I also submitted an Atlas of detail-sheets of a "Survey for a wagon-road from Fort Garland to Fort Wingate, N. Mex." This atlas of 14 sheets gave the details on a scale of 1 : 50,000 of a proposed wagon-route, for which an appropriation was requested. The report with its maps has been called for by the House of Representatives during the present session, and has been printed as Executive Document 172, House of Representatives, Forty-fourth Congress, first session.

The map giving all the latest information regarding roads and settlements in Northern New Mexico and Southern Colorado, which has been considered of especial value by the department commander, accompanied this report.

Upon the completion of this work, attention was given to the preparation of the general map of the Department of the Missouri, upon a scale of 1 : 1,000,000, and Kansas and a part of the Indian Territory were completed. A part of Colorado has been completed, and a part of New Mexico. An outline map on a smaller scale, 1 : 3,000,000, showing the various sheets already published by this office, was partly drawn up.

The field-work in the department during the past year has not been extensive.

The interchange of the Fifth and Sixth Regiments of Cavalry, and of the Eighth and Ninth Regiments of Cavalry, occupied so much of the time of these, the marching regiments, that little scouting has been done.

The quiet preserved by the Indians was unbroken, and no occasion for active operations arose beyond occasional rapid marches in pursuit of horse-thieves, when the rate of travel was too great for the taking of suitable notes.

The movements of the cavalry regiments were over roads measured since 1871, and it was not considered necessary to take additional or new notes of their routes.

There being no funds for special surveys, none were made, excepting a reconnaissance and survey of the Red River sources in Texas.

The total mileage of journals of March on the files of this office during the year 1875 was only 5,349, to 15,088 in 1874—a difference plainly accounted for by the above explanations.

There having been no regularly-detailed engineer officer for the district of New Mexico since Lieutenant Morrison was relieved in the spring of 1874 until lately, no reports have been received from that district, and no work of value done therein, excepting the continuation of the resurvey of the reservation at Fort Stanton.

The greater part of the office-work having been completed, I suggested to the department commander the propriety of my making a survey of the headwaters of the Red River of Texas. The suggestion was approved, and the necessary orders issued. I left this post on April 25, and, accompanied by First Lieut. F. D. Baldwin, Fifth Infantry, and Second Lieuts. C. A. H. McCauley, Third Artillery, and T. M. Woodruff, Fifth Infantry, the survey was conducted from Fort Elliott, Texas, returning there June 22, and to this post June 30.

The survey of this region in 1852 by Marcy and McClellan remained unsupplemented by additional surveys for twenty years, and no fuller

description was given, or more extended and minute surveys were reported, until the expedition of Col. J. I. Gregg, Eighth Cavalry, in 1872, gave a good map of streams of fresh water on the surface of the plains, 40 miles above the highest point reached by Marcy and McClellan. The route followed by this expedition was through the fresh water country to the gypsum regions of the Red River, where it issued from the Staked Plains, returning over a portion of its route. The connection of this line with other well-known surveys, such as the Canadian River or the Thirty-fifth Parallel Pacific Railroad surveys, was indefinite, having struck this line in but one point.

I had been anxious to verify the accuracy of this line, a prismatic compass and odometer one, for some time, but had no opportunity.

The Indian Territory expedition, under Col. N. A. Miles, Fifth Infantry, made extensive reconnaissances in all directions in this region in 1874–'75, and the reports were as good as prismatic-compass surveys can well be expected to be. These lines were compiled by myself, and the results embodied in my map of the Indian Territory in the southwest section.

Among these was a line from the Canadian to the Red River, thus connecting Gregg's line, as desired by me. The compilation made in this manner, independent of astronomical observations and chained or other so-called accurate surveys, made it somewhat doubtfully accurate, and I was anxious to compare and check the work by a deliberate and careful survey.

For this purpose I ran a stadia line myself from Fort Elliott to the head of the main cañon of Red River; thence completely around it by the south and east, closing with the line itself, touching the main cañon in as many points as possible. This stadia line has been checked by observations for latitude by the transit in the prime vertical, and for longitude by lunar culminations at two points. A prismatic-compass line was also run throughout the entire distance. Various small creeks and cañons were meandered by horseback reconnaissances or stadia lines or prismatic-compass lines, and the main cañon was carefully sketched as facilities existed. All, or the most, of available water in the region has been visited and located. The mileage made was about as follows:

	Miles.
Stadia line complete	260
Prismatic-compass line	450
Horseback reconnaissances	175
	885
Fort Dodge to Fort Elliott and return	370
Total mileage travel and survey by wagon	1,255

The general result of the survey has been very gratifying, inasmuch as it has proved that my maps have been well constructed and the methods of reconnaissance very good.

No serious error has been discovered in my Indian Territory map, and no serious omission. A trifling difference in latitude was noticed, and some omissions in topography, but the water-courses are correctly placed, both in location and in distance, as far as the survey extended. Of course, no attempt to make a careful reduction of the notes has yet been possible; but such platting as could be done in the field has shown the closeness of the work.

In addition to the geodetic work already described, a barometrical profile was taken over the entire line, with a mercurial barometer and two

aneroids. Observations for the determination of horary curves were carefully made, and comparisons made with the barometers of the United States Signal-Service station at Dodge City, and the record of the station during the survey will undoubtedly give an accurate and valuable profile over a section of country where such has been needed.

Attention was paid to the geology of the country, and fossils found in the sections in the cañons will determine the exact location of the strata. No fossils were found by Marcy and McClellan at the head of Red River, and, indeed, their scarcity and the few places where they were found easily account for their non-discovery by a party with as little time at their disposal as had these first explorers.

A full report will be made upon the ornithology of the region, as a good list of skins was obtained, and the time during which the party was out, May and June, was favorable for the finding of nests and eggs, and a large and full collection was made.

Land and fresh-water shells were collected, and will be reported upon.

The botany of the region could have been well studied in the survey, during the flowering season, and we made a full collection of plants. If I can find any one to make a report I will endeavor to secure it, my own knowledge of botany unfortunately being too limited to encourage an a tempt to write the report myself.

The entomology was also made a part of the natural history collection, and I believe the number and variety to be good.

If reports can be secured on these and kindred subjects from the specimens on hand, I doubt not that an interesting feature would be the result. Not having any funds at my disposal to secure the services of men who devote their attention to these matters, I shall be compelled to rely upon such assistance as officers of the Army familiar with such subjects can give outside of their regular duties. Fortunately I have already been much indebted to Asst. Surg. T. E. Wilcox and Lieut. C. A. H. McCauley, Third Artillery, in the course of preparation of the report, and I presume I can secure the aid necessary to make a finished report.

I made a series of water-color sketches during the trip, and selections made therefrom will accompany the report.

With the return to this post and beginning of the present fiscal year, I find myself without the services of my draughtsman, and within the last week Lieutenant Woodruff has been ordered on temporary duty outside of the department, and I lose his help in working up notes he was largely concerned in collating.

No other special work of any importance has been assigned to this office during the past year. The usual miscellaneous tracings have been furnished of varied subjects, and the usual number of maps have been distributed, as follows:

Maps issued during the fiscal year 1875–'76.

Titles of the different maps:	
Indian Territory, 4 sheets	172
United States military divisions and departments, 4 sheets	4
Kansas, Indian Territory, and Texas	6
Chickasaw country	3
Ute reconnaissance, 1873	3
Utah and Colorado	5
Nebraska and Dakota	1
Western Territories	4
Map of Kansas, (Jackson)	2
New Mexico and Arizona	1

Department of Missouri, sheet 2	34
Department of Missouri, sheet 4	31
New edition of Morrison's map of New Mexico	212
Total number of maps issued	478
Number of miscellaneous tracings made	30

I have stated what has been done and what could be done with the allowance shown by experience to be suitable for this office. An annual allotment of $5,000 would be of great service to the military service, and I have the honor to recommend such an estimate for this office.

SANTA FÉ AND TAOS ROAD.

In addition to the duties above described, I was placed in charge of the completion of the military road from Santa Fé to Fernandez de Taos in New Mexico, upon which work had been done in 1874. My report of this work at the close of operations then showed that while wagon travel between the two points named was possible, still the high hill to be crossed in the Embudo Cañon made additional work very desirable. An appropriation was made for this purpose in the sundry civil expense bill for the fiscal year ending June 30, 1876, and, together with the unexpended balance on hand from the preceding appropriation, $6,909.88 were available.

I personally superintended the construction of the road, and was engaged upon it from July 1 to September 11. The unfinished work in the Cañon of the Rio Grande above La Joya was completed, and the whole road from Cieniguilla to La Joya was thus placed in good order; a new route with easy grades, and a firm secure road-bed through this wild lava cañon, where before horses could scarcely pass.

Steep hills at the head of the Cieniguilla Arroyo, and at the crossing of the Arroyo Hondo, were avoided by new pieces of road, and travel from Santa Fé to Taos is now easy and uninterrupted.

This road has been of great local benefit to Santa Fé by allowing an easy access to the wheat region of the Taos Valley, whence hitherto flour had been drawn exclusively by burro pack-trains. Besides this advantage, a shorter route to Pueblo, the railroad terminus, was opened, and light travel began to pass over the road Since that time, however, renewed activity in railroad building has been shown in Colorado, and Pueblo was reached by the Atchison, Topeka and Santa Fé Railroad. The Denver and Rio Grande Railroad extended its line to Trinidad, to the south, and is now building to Fort Garland, across the Sangre de Cristo range. This has entirely altered all freighting condition in New Mexico, and where a year ago the freight-trains passed over a road of 312 miles from railroad terminus in Colorado by the south and east of the mountains to Santa Fé, they will shortly be able to go from Fort Garland to Santa Fé by the west of the mountains, and over 150 miles only. The saving to the whole southern and Rio Grande Valley country of New Mexico will be the same, and the line to the southwest and Arizona will be equally or more shortened. This altered condition brings the Santa Fé and Taos road into prominence as a general public benefit rather than a local one, and I trust the whole of New Mexico will realize this fact in the cheapening and quickening of freights.

This will not be done, however, unless the work of improving and straightening the road be continued from Taos to Fort Garland.

This has been very little traveled until of late years, and the portion between Taos and the Rio Colorado is very difficult and requires some money and care to place it in good order. I recommended that an

appropriation of $10,000 be asked for this road, and the department commander approved the suggestion, and the report was forwarded for the consideration of Congress.

It is to be hoped this will be granted, as the general nature of the expected benefit, and the unlikelihood of the impoverished community of the vicinity being able to build the road themselves, make the request a proper one, and if granted the result will be of immediate value to the military service and to the general public.

Appropriation Santa Fé and Taos road, 1876	$6,644 80
Unexpended balance, 1874	265 08
Total amount available	6,909 88
Amount expended	6,314 53
Unexpended balance	595 35

For the present year, there being no funds on hand and none appropriated, no work is contemplated for the engineer office of the department, and the preparation of the various maps on hand is suspended for the present.

I am, sir, very respectfully, your obedient servant,

E. H. RUFFNER,
First Lieutenant of Engineers.

The CHIEF OF ENGINEERS,
United States Army.

REPORT ON LINES OF COMMUNICATION BETWEEN SOUTHERN COLORADO AND NORTHERN NEW MEXICO.*

The long detour in passing from the present end of railroad communication in Colorado to Fort Wingate in New Mexico has made a shorter route desirable for some years past. With a view to improving and shortening this route, the department commander directed an examination to be made under the orders of the commanding officer of the district of New Mexico, and in 1872 the acting engineer officer of the district, Lieut. C. C. Morrison, Sixth Cavalry, was engaged for two months in a reconnaissance of several routes. The results, though valuable, not being conclusive, the subject was again considered, and verbal directions guided the design and main features of the survey now to be reported upon. A schedule submitted by myself was approved, and was carried into effect as detailed in the report of Lieut. G. S. Anderson, Sixth Cavalry, to whom was given the direction of the survey. I myself at the time was engaged in the personal supervision of the construction of a wagon road from Santa Fé to Taos, N. Mex.

From Fort Garland to West Las Animas and to Pueblo, fine wagon-roads have existed for many years. From West Las Animas to Pueblo, a projected line of railway was at that time in contemplation, and is now in process of construction as a continuation of the Atchison, Topeka and Santa Fé Railroad from West Las Animas, to which point it has recently been extended. The Denver and Rio Grande Railway have graded a line from Pueblo south to the Cucharas River, and at the time of the survey were not only working on this line, but talking of still further extension to the west, even into the valley of the Rio Grande.

* Printed in Ex. Doc. 172, House of Representatives, Forty-fourth Congress, first session.

For these reasons I selected Fort Garland as the best point to the west of the Sangre de Cristo range from which to start the survey.

The general direction chosen was south-southwesterly to the head-waters of the Puerco River, near the northwestern extremity of the Gallinas Mountains, where connection would be made with the work of Lieutenant Morrison. Lieutenant Anderson left Fort Lyon with his party May 30, 1874, and, commencing his survey at Fort Garland, was engaged in the work until July 15. He then broke up the party, and, returning to Fort Lyon July 20, reached this place July 24, submitting his report immediately.

Owing to the commencement of hostilities in the Indian Territory, Lieutenant Anderson was not allowed to prepare as full a report as would have been desirable, and as he was in the field for six months, and shortly afterward his regiment was ordered to Arizona, I have not been able to obtain as complete details as many points require.

I shall now proceed to give a brief description of the present lines of communication between the railroad and Fort Wingate, and then, by comparison, invite attention to the principal features of the new route.

DESCRIPTION OF EXISTING LINES OF COMMUNICATION.

From the Arkansas River to the southern points of the Sangre de Cristo range.—The present point of departure for New Mexico from the railroad is West Las Animas, Colo. The recent extension to this point from Granada of the Atchison, Topeka and Santa Fé Railroad has concentrated here for the present all trade passing over this and the Kansas Pacific Railways. The route followed by freight to the south is known as the Dodge road. This, going to the east of the Raton Spur, avoids the pass of that name, and is more direct. It joins the stage-road, which goes through Trinidad, in the vicinity of Fort Union, and is by some 18 miles the shorter of the two. The regular stage-road from Pueblo to Fort Union is only 5½ miles longer than the short road from West Las Animas to Fort Union, and the farther extension of the railway up the valley of the Arkansas to Pueblo, as is proposed, would not materially alter the freighting distance to New Mexico, so long as it shall be necessary to make the easting requisite to pass the Raton Mountains, a condition apparently unavoidable by the east flank of the range.

From Fort Union to the south a distance of about 20 miles is required before the chain of mountains to the west can be approached in making the change of direction toward Santa Fé and the western portions of New Mexico. In this 225 miles of distance from the Arkansas to Western New Mexico, about 177 miles are southing, while only about 122 are westing. If, however, the railroad terminus should be even as far west as Pueblo, 86 miles farther up the Arkansas River, the condition would not be bettered, as the same southing would be required and the only westing made by wagon-road would be 36 miles, although the total distance traveled would be the same.

Along this portion the conditions are favorable to freighting. The grades are very good, with the exception of the passage of the Raton Mountains, which now, in the long easy slope of the customary route, presents no serious obstacle. The grass and water are ample in quantity and good in quality. Delays occur frequently from incidents of the weather—unusual snows at times, heavy rains in the rainy season, or protracted drought at other periods. Still, these delays do not seriously embarrass trade nor extend over many days at a time. The alti-

tude of the highest point—the Raton Pass—is not great enough to make any practical difference in winter or early spring between this and other portions of the road, and in fact the uniformly high altitude of the whole area in question renders the climate more dependent upon this condition than on the element of latitude; and if the route is in good condition in one portion it is apt to be so in all. In the rainy season-storms sometimes cause the streams to rise so as to be impassable; but this is exceptional, and the delay is rarely more than a day or two, or long enough for the water to run out. The most important of these streams are bridged. A daily line of stages runs from Pueblo and West Las Animas, joining at Trinidad, via Fort Union and Las Vegas, to Santa Fé.

From south point of the Sangre de Cristo range to the Rio Grande.—The next section of the route to be described is that embracing the various roads passing from the east slope of the mountains to the valley of the Rio Grande. Of these, the most northerly is that up the valley of the Pecos River, and thence via Santa Fé to Peña Blanca on the Rio Grande.

The most southerly pass is via Anton Chico and the cañon Blanco to Albuquerque, and is perhaps 30 miles farther south. The character of the country now becomes different from that previously encountered. The smooth roads of the prairie are replaced by rocky hills at times, and at others sandstone strata nearly horizontal in position make the road difficult and the grass scanty. The cañons and sandy or gravelly ridges of the elevated plateau upon which Santa Fé is situated are succeeded by the sandy valley of the Rio Grande, and throughout the whole region the abundant grasses of the eastern front of the mountains are succeeded by a scanty growth, which a delayed rainy season will almost cause to disappear. In the cañons of the more northerly route, the snows of a late spring sometimes cover the grazing-pastures to such an extent that the starving cattle of the freight-trains, dependent entirely upon this fortuitous grazing, can hardly drag light loads over the heavy roads. Although the main chain of lofty mountains abruptly breaks down in the vicinity of Santa Fé, still the plateau itself maintains its high altitude, and is nowhere lower than 6,000 feet, continuing in a southwest direction until south of Albuquerque, when high mountains again appear. Isolated masses like the Placeras and the Sandia Mountains form obstacles which are avoided only by following down the cañons which seam their sides. From this plateau to the valley of the Rio Grande, by all the routes, necessitates a descent of 1,500 feet in from 10 to 18 miles. The greater portion of this fall is by one road concentrated in one tremendous hill at La Bajada. The ascent to this plateau from the east is fortunately more gradual, and from Anton Chico, which has about the same elevation as the Rio Grande at Peña Blanca, from 30 to 40 miles may be given as occupied in the rise. The valley of the Rio Grande is fortunate only in the abundance of good water. The universal occupation of tillable ground by a crowded population allows no pasturage that is not already overstocked, and the sandy mesas furnish a scant substitute, which is only too kindly described as "poor." The roads are good in some places, but are more often sandy. The only route, however, in which the valley of the Rio Grande is followed for any distance is in going from Santa Fé via Algodones and Albuquerque, where 23 miles are located in the valley.

From the Rio Grande to Fort Wingate.—From the Rio Grande to Fort Wingate two routes are followed: the lower, via Albuquerque, 124 miles; the upper, to the west from Peña Blanca, 150 miles.

The latter, passing through the rolling foot-hills of the Valles and Jemez Mountains, and across the shattered remnants of the extremity of the lava-field of the Rio Grande, is tedious with sand, and broken with low gravel-hills as far as the Jemez River at San Ysidro. Scanty grass is the rule, and there is no water between the Rio Grande and the Jemez.

After leaving this portion, the road improves, and, although rolling and broken, the lava formation of the first few miles no longer appears, and the absence is not a loss.

At the Rio Puerco, the new or proposed route comes in from the north, and from this point to Fort Wingate the two coincide. Water can be found every 12 to 18 miles; the grazing improves in quality and quantity as one goes farther west; and the road is fair—never very good, never very bad—with sand and clay. The lower route meets the same obstacle after crossing the Rio Grande. Heavy sand-hills and a desolate rolling country separate the dry bed of the Puerco from the Great River of the North. Upon reaching the bed of the San José, a good road is met. Gypsum disappears, muddy pools become a running stream, and there are agricultural spots. At Blue Water, 38 miles to the east of Fort Wingate, the other route is joined. These two lines deviate from a direct line in order to pass the imposing mass of Mount Taylor, and one passes to the north as much as the other to the south. This huge peak rears its lofty form, superb in grandeur and regal in its isolation. Scarred volcanic rocks drift down its sides and are lost in its vastness. Its huge base of 30 miles in length and 15 in width forms a worthy foundation to the structure, piercing to the skies. Easily seen from Santa Fé, 100 miles to the east, it is the monarch of these desolate, weather-worn, and wasted lands. Sandstone mesas, water-washed, reach out from the mountain's skirts and repel approach.

Over both routes freighting can be done, and easily; but the difference between the "plains" and these barren mesa-lands, with their scattered pools of water and scant grass, is very great. Over the upper road a regular mail-route has recently been established, a buckboard going twice a week from Santa Fé to Fort Wingate and returning.

Although freighting, and, indeed, communication of every kind, had heretofore passed from the east to Fort Wingate by the route just described almost exclusively, still it is not the only way in which it might be done. In lieu of making the detour around the Santa Fé end of the mountains, they may be crossed to the north, and the road correspondingly shortened. As will be shown, there was good reason why this was avoided until very recently, and for further reasons it will always be accompanied with objections unless natural obstacles are converted into aids.

By Fort Garland and the west of the mountains to Santa Fé.—Wagon communication between Pueblo and Santa Fé, by the western side of the Sangre de Cristo range, has been possible for many years. It has always been very difficult until recently; but with the completion of the military road from Santa Fé to Taos, a great improvement has been made. From Pueblo, or, indeed, from Las Animas, to the passes, we find excellent wagon-roads over hard prairie or by the slopes of the foot-hills. Abundant grazing and good water can always be found. The country is well populated with stock-farmers, and there is also increasing attention given to agriculture. The stage-road from Pueblo to Trinidad passes by ranches wherever agriculture seems possible; and, indeed, the recent conversion of the gravelly, barren mesa south of Pueblo into

a beautiful village, with shady streets of green trees, strikes the traveler from the Eastern States as little short of miraculous.

Crossing the mountains.—The mountains are crossed by toll-roads built over the Sangre de Cristo and Abeyta Passes. By long, gentle slopes, the ascent is made up the valleys of mountain-streams, with abundance of good grass, water, and timber at every spot. The approach to the summit is steep but short, and the descent on the western side is very gentle, and is made through similar surroundings. The beautiful high valley at the summit seems intended to invite a rest before encountering the monotonous plains on either side, or after the fatigue of the ascent. The snow need not block the passes longer than the plains. With sufficient travel to keep the road clear, there would not be any interruption during the year. A fall of snow remaining on the plains would of necessity stop all freighting, but when it melts there it will also in the pass, except in a few narrow and short cañons which could be cleared if necessary. There was no interruption during the winter of 1874–'75.

The San Luis Park and its roads.—The San Luis Park is entered at the foot of the pass, and at this point Fort Garland is situated, 81 miles from Pueblo and 161 miles from West Las Animas. From Fort Garland to the west and north, through the San Luis Park, 55 miles of natural road form the commencement of the route to the San Juan mining district, 38 miles to the southwest over an excellent natural road, excepting only the crossing of the Rio Grande, forms the first section of the proposed route to Fort Wingate and Arizona, 55 miles to the south over the same excellent and level road, furnished by the San Luis Park, will bring us to the Rio Colorado on our way to Santa Fé. A fine grazing country, with abundance of mountain-streams, the only drawback is perhaps that the number of cattle on the range is too great, and the pastures are overstocked.

We now commence to cross the foot-hills which reach out to the river or near it, and the Park is left with many feelings of regret and longing for its beautiful roads.

Rio Colorado to Taos.—From the Rio Colorado to Taos, about 25 miles of bad road are encountered; steep hills, up and down which the road goes without the slightest regard to the action of gravitation, are additionally annoying to any one who will notice how easily they may be turned or the road relocated on reasonable grades. The soil is good, and grazing abundant, and water is found almost anywhere.

The pine forests of the mountains come down over these foot-hills, and there is a surprising quantity of fine timber. The valleys of the streams are found in cañons, and the lava-field of the Rio Grande has spurs stretching up these cañons to the permanent ruin of all roads found therein. In order to make this section of road really safely passable, work must be done between the Rio Colorado and Taos to considerable extent.

In the valley of Taos is found at present the most valuable agricultural district in New Mexico. A population of 7,000 is engaged mainly in the cultivation of wheat and corn. Two flouring-mills are supported in the manufacture of what is considered peculiarly fine flour. Large quantities of this flour are consumed in Santa Fé, and during the past year the contract for Fort Union was held by parties who filled it from this region.

Taos to Santa Fé.—Between Taos and Santa Fé there formerly existed a very disagreeable passage by a steep and bad road over a mountain-spur reaching from the main chain to the cañon of the Rio Grande. This spur, called the Picuris range, could be avoided only by a long

detour, crossing the Rio Grande twice. Freight, except such as could be carried by burros, was almost prohibited, and the customary route for individuals going from Santa Fé to Fort Garland was via Fort Union and the Sangre de Cristo Pass in preference to attempting the more direct line.

Now, however, through the munificence of the General Government, a new road has been constructed down the cañon of the Rio Grande, and a level route, straighter than either of the old roads, can accommodate all possible travel.

The last 40 miles of this route pass through a country remarkable for its barren desolation; hills of drifting sand or gravelly soil support almost nothing, and every spot capable of cultivation is occupied. Freighting by cattle-teams must always be very difficult through this region. It should be remarked, however, that the approach to Santa Fé from any direction is but a slight improvement on this picture. Arriving at Santa Fé from Pueblo, we have saved 81 miles in distance over the present stage-road via Trinidad and Fort Union. With the improvement in the road made between Taos and the Rio Colorado, this line would be far preferable as a stage-route from Pueblo to Santa Fé and the south, and, as it is, several days may be saved in travel by Government teams passing between the two places, and drawing their forage from the regularly-established agencies. From Las Animas to Santa Fé the two routes differ only by 8 miles, and each extension of the railroad up the Arkansas River will shorten the distance by the west of the mountains without influencing that on the eastern. We have now looked at all of the existing routes to the region in question.

Perhaps, were the freighting conditions equally as good by the west of the mountains as by the east, there would be no cause to improve upon the route last described. But we are here confronted by two rather remarkable physical features of the country, which it might be interesting and instructive to describe.

Lava-field of the Rio Grande.—In the first place, there is the lava-field of the Rio Grande. This is a tremendous exhibition of volcanic power. Commencing at the angle between the Conejos River and the Rio Grande in Colorado, one continuous sheet covers the face of the country to the south for 80 miles unbroken, and then for 50 miles farther is now exhibited in outlying areas and detached masses, separated from the main body only by the exercise of the power of erosion through prolonged ages. One hundred and thirty miles in length, and perhaps 30 in breadth at its widest place, the area of a principality lies swallowed up forever. From craters existing probably in the San Antonio Mountain and the Ute Peak, and possibly in other centers, this flood poured over the land. Reaching to the east, it was checked by the mountains of the Sangre de Cristo range; flowing to the west, the mountains and hills of the main divide and the spur now between the Chama and the Rio Grande limited its extent. To the south, it was deflected westwardly by the spur of the mountains called the Picuris range, some 15 miles south of Taos. Protected by this spur, we find the east bank of the Rio Grande for many miles free from the flua. Confined on the west by the slopes of the Jemez Mountains, the breadth of the field is narrowed; but from the village of San Ildefonso to Peña Blanca we find the lava on both sides of the Rio Grande, spreading to the east as far as the valley of the Santa Fé Creek. Secondary centers in the Jemez Mountains possibly contributed to this extension, but the main force of the eruptions was probably felt farther to the north.

However, in this vicinity, the edges and extremity of the field have been reached, and there has been so much erosion at places since its deposition that outlying masses, as in the bluffs to the west of San Felipe, alone remain. Throughout the whole region thus depicted, this lava-field is the great and controlling element. The streams that have eaten their way through it with untold difficulty are found in narrow and deep cañons, having no land for cultivation. A dangerous feat for man to descend these precipices, the passage for any animal is almost impossible. The Rio Grande passes for 80 miles or more through its black abyss, with walls of seven or eight hundred feet in height, crowned with perpendicular cliffs of solid lava two and three hundred feet high. Throughout the whole region there is no agriculture. The valley of Taos is formed only by the fortunate detrition of the adjoining mountains spreading over the edges of this plain a thin soil. Outlying patches are cultivated at other points near the perimeter of the basin. Agriculture on the Rio Grande is possible only, as before alluded to, in the section that was, so to speak, in the lee of the Picuris range, or from La Joya to San Ildefonso. The surface of the mesa itself supports a scanty grass which feeds a few wandering flocks of sheep, and the dwarf cedar proves anew its wonderful hardiness. In consequence of these features, roads across this country are almost an impossibility. From Cienigilla to the Ojos Calientes is found the only wagon-road crossing the mesa from east to west.

The fortuitous cañon of the Rio Chama furnished a route from Santa Fé to the northwest. From Peña Blanca to the west, the road is possible because of the erosion of bluffs, which were probably as formidable once as those of San Felipe, 10 miles to the south.

The road from Fort Garland to Taos keeps to the east of the basin, touching it only at the Rio Colorado and at the Arroyo Hondo. Lieutenant Morrison's route in 1872 is unavailable because of passing over the western shore of this no longer sea of fire, where sterility and absence of water are the rule.

In the construction of the military road from Santa Fé to Taos it was necessary to follow the cañon of the Rio Grande from La Joya to Cienigilla, and the expense of the construction arose from the necessity of passing through the blocks of lava forming the *débris* at the foot of this gigantic mesa cliff.

Under these conditions, the problem of passing to the west of this section becomes a strategic one of turning its flanks. The routes via the south point of the Santa Fé range turn it to the south as well as the range itself. The proposed route will turn it by the north.

The marls of Santa Fé.—The second physical feature remains to be described. Underlying this gigantic field of lava, probably throughout its whole extent, certainly in its southern portion, there exists a series of immense beds of marl, sands, and clays, and imperfect sand-and limestones. Of many hundreds of feet in thickness, the coarse character of the sand and the immense quantities of gravel show that they are formed by the very rapid erosion of a lofty mountain-range. From this cause the formation of a finely comminuted soil has been impossible. Barrenness and desolation are the results, and the country to the south of the Picuris range and Santa Fé and its vicinity suffers accordingly.

The foot-hills of the mountains and the valley of the Rio Grande are alike sandy and sterile. Narrow strips of ground are irrigated in the immediate vicinity of the streams, but away from these feebly green spots aridity and bleakness extend. There is no grass except during the

few weeks succeeding an usually protracted rainy season. Cattle learn to eat anything that is green, and the sight of the goat eating the thorny stems of the tall cactus is no more striking to the stranger than to see the gaunt ox feeding on the running pine and the dwarf cedar. Sheep and cattle are driven from this region to the "Conejos Country," full 60 miles, to pasture and to winter. The valley of the Chama is similar in its character, being formed by the excavation of the same beds of marl, and the Rio Grande below the junction of this stream never loses its predominant characteristic of sand. These marls extend to Santa Fé and farther south. The Santa Fé Creek irrigates a small portion of tillable land some 6 miles or more in length in the immediate vicinity of Santa Fé. Besides this, and a starving hamlet at Galisteo, no sign of civilization breaks the desert solitude of sand and gravel that stretches southwardly down this elevated plateau, save the isolated ranches near the rare springs of water, such useful oases in the passage of this divide. The civil division of the country of Santa Fé very nearly covers this barren area from the Rio Pojoaque to Galisteo. In this country, with a population, by the last census, of 9,699, there is reported as the total area of improved land 10,925 acres only, with a total annual value of farm products of $99,410, or about $9 per acre. This in a country where corn is cheap at 2 cents per pound. The production of wheat was given at 6,314 bushels and corn 20,262 bushels. Beyond necessary working-cattle and horses, no stock except sheep are kept in this region; 630 having been reported as the total of "other cattle" held in the country. To avoid the lava-field in going to the west by the south from Fort Garland, we necessarily encounter at least 67 miles of this desert.

It might not be an impertinent digression at this point to answer the question, Why was Santa Fé established in the face of these disadvantages? Its lovely climate, protected as it is from the north by its near mountains, and elevated at 6,840 feet into an atmosphere charming in its freedom from moisture and balmy in its mildness, may perhaps have had its influence. An abundance of excellent water is found at a short depth by digging wells at almost any point of the locality, and fresh and sweet; it alone in those regions is reason sufficient for settlements. The immediate vicinity probably supplied its earlier inhabitants with sufficient food for their limited numbers. By reason, then, of these two formidable features, it has not been advisable heretofore to use the route thus described in passing from Colorado to Western New Mexico. As shall be shown, however, it is more than probable that early progress in railroads shall make this route a desirable one to Southern New Mexico in case it shall be improved, as indicated before, between Taos and Fort Garland.

It is now necessary to describe the lines of reconnaissance and survey examined in search of a new route, and to give a general view of the country through which they pass.

DESCRIPTION OF NEW ROUTES SURVEYED.

Lieutenant Morrison's route in 1872.—In 1872, Lieutenant Morrison made a reconnaissance by the west side of the Rio Grande Crossing the river at Meyer's Ferry, he went down the lava-field near its western edge to Ojo Caliente; thence by a long curve to the west and north he crossed the Chama some 53 miles from Ojo Caliente; from this point down the course of the Puerco to the road from Peña Blanca to Wingate, and with it to that place. Unfortunately, his report was not as full

as it might have been, and I shall endeavor to supplement it from other sources.

It is an interesting historical fact that during the suppression of the Indian insurrection in New Mexico by the Spaniards, in 1690–'93, an expedition to conquer the Pueblos of the Taos Valley, having been longer in its undertaking than presupposed, found itself blocked up on its return to Santa Fé by snow in the Picuris range. Fearing to attempt the passage under the circumstances, the plan was adopted of going north into the Utah country, now Colorado, crossing the river above the cañon of the river Grande, probably in the vicinity of the Rio Costilla, and then returning to the south. The line of march on the west side of the river was the same as that followed by Lieutenant Morrison, and the lapse of one hundred and eighty years has found us in nearly as intimate a knowledge of this country as the Spaniards had then.

Conejos to the Chama.—The lava country, of course, through its whole extent furnishes hard roads, level in stretches, and very rough from detached fragments, which have an almost perfect hardness, weathering very slowly, and never crushing into macadam. The cañons of the water-courses on this route and the edges of the field are descended by very rough and very bad roads, incapable of permanent improvement, and not even easy to be bettered.

The longest distance without water is 25½ miles, being that from leaving the Conejos and its tributaries to some water-holes on the lava-field. The last stretch of 17½ miles into Ojo Caliente is without water, and as the road has left the lava, the sand of the marl formation thus discovered makes the traction difficult.

Rolling country and steep hills between Ojos Calientes and the crossing of the Chama, in addition to the undesirableness of the preceding section, do not tend to reconcile one to the long detour thus made between the Conejos and Upper Chama in order to avoid the mountains of the direct line. In this section, Lieutenant Morrison examined three routes, and of these recommended one which would necessitate some work before it could be used by wagons. The others have objections to their use in being longer and in other features of a physical character.

Were the curve of the more level route located through a prosperous region, or were the roads smooth and quickly traveled, with good grass and abundant water at reasonable distances, it might not be considered worth while to attempt to shorten the line by passing over a chain of mountains. But when the mountain-route has the usual advantage of water at all points and good grass, and its grades are fairly reasonable, the question of cost of construction may well be considered. And when in addition to this the saving in distance, as in this case, amounts to 55 miles, the economy of a judicious investment is well-nigh manifest.

The Jemez Mountains.—The mass of the Jemez and Gallinas Mountains necessarily deflected Lieutenant Morrison's line, and the northwestern point of this obstruction was the objective from Fort Garland selected by me in the line surveyed. The mountains form a bold and imposing feature in the landscape. Rising in swelling masses and terraces, they are always grand in effect and graceful in outline. Culminating in one high summit, every defense of bastion and outlying rampart seems combined for its protection, alike from the attack of man or the fiery onslaught of nature. Though lofty enough to be surrounded by the summer-clouds and darkened by the summer-storms,

these mountains are not of sufficient area to form and protect mountain-streams, as does the Sangre de Cristo range. Agriculture, therefore, is represented only by the scanty fields of the Jemez River or the withered banks of the Puerco. No communication exists through its forbidden cañons, nor, indeed, does the prospect even invite a search.

Rio Chama to Wingate.—To the westward still we find the great Atlantic and Pacific divide, with a general direction of south-southwest. Having turned the Gallinas Mountains, our crossing of the Rio Chama is found to be probably not more than 15 or 20 miles to the east of the crest of the divide. From this point to Blue Water station, a distance of 147 miles, the road is sensibly parallel to the line of the crest. Bacon Spring is found on the west, and is the first water encountered on the Pacific slope.

The general character of the country, from the line of the road to the north and west, is very much the same everywhere. Recent sedimentary rocks, and soil from their detrition, are the geological features. The altitude of the divide is not great, rarely over 7,000 feet, and the rain-fall is very slight. But the soft soil washes very easily, and the water-courses to the west become cañons at short distances from the sources. Two of these cañons have been carefully examined and described.

The Cañon del Chaco was reported by Lieutenant Simpson, in 1849, to contain remains of a former population of considerable size. Its rocky walls now look down only on a dry bed and dusty ruins. Pueblo succeeding pueblo formerly lined the banks of what must have been a fertile river-valley. To-day not even is it safe for the passing train to depend upon finding sufficient water there except during the rainy season.

Capt. J. N. Macomb passed through the Cañon Largo in 1859, finding it still more desolate than the Cañon Chaco, although exhibiting ruins indicating former habitation. The great divide itself is not a precipitous chain of mountains, but rather a rounded plain, and the whole country is made up of approximately plain surfaces, now cut up into gigantic sandstone mesas, crumbling, dry, and barren. The only routes that can be followed are by the gorges between. It is impossible to cross the system, save with much work and many detours. The topography of this feature is well illustrated by the detail-sheets of the accompanying atlas and also by the general map.

However desirable it might be to rectify the line of the route between Chama and Fort Wingate, it would be difficult, if not impossible, to do so with a wagon-road. If we pass to the west, we shall find ourselves on the dry crest of the divide; if still farther to the west, we are in a dearth of water, and a difficult line of travel for all possible reasons.

New route proposed for construction.—Having thus discussed existing lines and the difficulties encountered, the remainder of the description is confined to the portion which is recommended for consideration as to the propriety of constructing a new road. From the Rio Conejos to the Rio Chama, the line surveyed is reasonably direct; the distance, as the crow flies, between the two extremities being about 53 miles, while the route chosen by Lieutenant Anderson is 64 miles in length, a very slight difference, if it is recollected that 10 per cent. is the usual allowance in the difference of distance between a mountain, or even rolling country-road, and one on the level between two points with the same air-line distance. With this allowance, the curvature will be less than 10 per cent.

As can be seen from the details given in Lieutenant Anderson's report, all the essentials for freighting are found at all points. In passing the divide, the line follows the course of some stream all the time, and thus, as in all the mountain-passes in this region of country, the facility of stopping wherever desired makes the passage easier. The distance to be worked is 64 miles, and the route chosen by Lieutenant Anderson is approved, with the correction of passing directly down the entire valley of the Nutrias to the ford of the Chama. It is to be noticed here that one objection to this route lies in the fact that there may be snow on the pass during the early spring. In all probability, when the Sangre de Cristo Pass is free from snow, these mountains will be equally clear, and, at any rate, nine months in the year certainly will be available for all kinds of travel. In the construction of the road I believe the idea of soldier-labor had best not be entertained. The constant employment during the season of cavalry, and the frequent calls for infantry, would make their labor difficult to procure, fitful, and expensive.

The New Mexican settlements on the Conejos and at Tierra Amarilla are numerous, and would furnish all the labor necessary and at reasonable rates. From my own experience with Mexican laborers, I feel safe in saying that it would be difficult to hire as good men at higher wages in portions of the country where more frequent opportunities of such employment may be found.

I have not been able to collect as exact information concerning the settlements on the Chama as I could wish. From personal acquaintance I know, however, that the Tierra Amarilla country is considered by the inhabitants of the Rio Grande district to be good land, and, as this is supported by the census, it is probably correct. During the ten years from 1860 to 1870, although the population of the two counties, Taos and Rio Arriba, has decreased a few hundred, there has been an increase of about a thousand souls in the Abiquiu and Tierra Amarilla precincts; this change being undoubtedly from emigration from the other portions of the counties. The quieting of Indian troubles has probably led to this result, as this region is considered much more favorable to stock-raising than farther to the east. The transfer of population referred to is almost entirely concerned with the native Mexicans, and one acquainted with the strength of local ties of this race knows that starvation, or hopes of betterment, or both, would be required as incentive sufficient for such emigration. The grazing in this vicinity and in what is known as the "Conejos country," the high land of the northern end of the proposed road, is considered fine enough to warrant the driving of flocks of sheep from the Rio Grande, near the mouth of the Chama, to this pasturage, a distance of at least 60 miles, and cattle are also driven to this region for wintering from the same localities.

What is known as the old "Spanish Trail" to the west passed from Santa Fé up the Chama and through the Tierra Amarilla country, thence crossing the tributaries of the San Juan near the foot of the range. This was surveyed by Capt. J. N. Macomb, 1859. Since the opening of the San Juan mining-region there has been considerable travel by this route to the mines, passing up the Animas River.

The impulse to trade has been slight, but it has been something, and merchandise from Taos and from Santa Fé has gone in this direction. All things considered, this immediate section is the only one in the northern and western portions of this Territory which has an upward look.

GENERAL VIEW.

Having now completed our particular examination of local regions and lines, I propose to give a general view of the situation, embracing both natural and artificial features.

The active rivalry of three railways—the Denver and Rio Grande, reaching to the south; the Atchison, Topeka and Santa Fé, to the south and west; and the Kansas Pacific, endeavoring to prevent the two former from cutting off its resources in those quarters—has already produced valuable results to New Mexico and to the public at large, whatever be the effect upon the owners of the railways or their creditors. Each effort of one to extend its reach is met by a corresponding move on the part of the other. At the moment of writing it is asserted that the rails will be laid from West Las Animas to Pueblo by February next, also that by the same time the Denver and Rio Grande will have ironed its track to the Cucharas, fifty miles to the south of Pueblo. The Kansas Pacific has laid a few miles of track to the south of the Arkansas, and talks of reaching Trinidad in a short time. There is no doubt, at any rate, that all will be done that can be with the resources at command, and that the extensions will be only a matter of time, means, and natural obstacles. Railroad building in the valley of Arkansas, and even over the prairies, is a different matter from construction among the foot-hills of the range, or from the problem of crossing the latter. The north and south line of the Sangre de Cristo range presents an almost unbroken front from the Arkansas River Cañon to Santa Fé, and certainly at present the prospect of its being crossed is not good. While there is nothing very difficult in construction to be encountered, the expense would be much greater than on more level ground, and the grades would always be heavy and the running expenses proportionately great. A uniform grade of 150 feet at the least to the mile would be necessary for 14 miles to make the pass, or more likely lighter grades at first and heavier near the crest. While this can be done, and the experience in the cañons of Colorado near Denver show that it may be advisable, still in this case there are no rich and well-established gold-mines at the end of a short route, but instead thereof very little trade, and that to be fostered and built up, and it is altogether unlikely that this passage will be attempted immediately. Again, in the direction of Trinidad, the bold and high spur of the Raton Mountains offers to the southern passage grades almost, if not quite, as severe as the other line. The continuation of this spur to the east by the Mesa de Mayo and the cañon of the Dry Cimarron has indeed formed the great obstruction to railroad extension toward New Mexico from Kansas and Colorado heretofore. For the same reasons as in the preceding case, it is not likely that any prolongation of either of these lines would be made beyond Trinidad for several years, even supposing the inducement of the fine coal of the vicinity attract them thus far. In all probability, then, two points, one Trinidad, and the other not far from the foot of the Abeyta or the Sangre de Cristo Pass, may be considered as the virtual termini of the system of these three railways.

From Trinidad the southern trade can be reached by the present stage-road over the Raton Pass, and as wagon-roads are being constructed or improved up the Purgatory to the Moreno mines, and across the range to Costilla, in the valley of the Rio Grande, a new system will here be opened.

Through the Abeyta Pass, the trade of the San Juan mining country will go, and probably some of the Santa Fé trade also. In case of the

improvement of the road from the Rio Colorado to Taos, all the military freight for Santo Fé and for Southern as well as Western New Mexico will undoubtedly pass this way. From either point no advantages can be obtained by a farther southern extension which cannot be as well gained, together with others, by a westward direction into and over the range. If we now examine the map, and recall the physical features already described, we shall see that from these two points we must have converging lines to the west, the one from the more northern point crossing the range and the Rio Grande to the southwest; the other, from Trinidad, must cross the Rio Grande above its cañon, and the two naturally intersect at the villages on the Conejos or the initial point of my survey. This, then, is the key of the whole situation. If the shipping-point be the Cucharas, the better of the two, the shortest and best line to the southwest is that direct to this point; if from Trinidad, the result is the same. From the location of the initial point, the next step is a certainty. The Rio Puerco must be reached by the shortest line, and then it must be followed.

It is impossible to locate a general route to the west of this line, because of the bad lands of the Atlantic and Pacific divide, and it would be unadvisable to select a direction to the east, because of the lava-field and the Jemez Mountains. It would be unwise to remain on the east of the Rio Grande, because of the detour to the south and its features. A careful consideration of these general conditions leads us to the conclusion that for many years the shortest, best, and most advisable wagon-road will be located about as described and recommended for construction.

It only remains to call attention to the needs for such a road and its advantages.

INTERESTS AFFECTED BY PROPOSED ROAD.

The post of Fort Wingate was established when the Navajo Indians were removed from their reservation on the Pecos River to their present one, the latter being their native home before their subjection by the Army. The garrison is intended as well to protect these Indians from the whites as to impress upon the former that they are no longer the lawless marauders of the preceding decade. The tribe is the most important one in New Mexico. They are intelligent and superior physically to any other of the neighboring natives. They have always maintained a high reputation for innate industry, having engaged in agriculture as well as in manufacturing many articles of domestic life. They are now quiet and law-abiding, and are reported to be anxious to improve, and are willing to work. In fact, if there be any prospect of a radical improvement in the red man in this region of country, the Navajos offer the only hope to the sanguine. They number over 9,000 now on the reservation, and are considered not to be decreasing in numbers. They are contented with their reservation and their fate, and we cannot foresee any likelihood of a change in their temper, feelings, or welfare likely to lead to a change of location.

The garrison at Fort Wingate is, therefore, the most permanent as well as the most important in New Mexico, and good communications to it from other posts and from the supply-points should be more carefully sought for than to any other points. Two companies of cavalry and two of infantry have been the ordinary garrison, and subsistence-stores, clothing, and camp and garrison equipage, and miscellaneous quartermaster stores must be freighted there from the East. The estimated annual allowance for such a garrison is about 628,000 pounds. The

post of Camp Apache in Arizona has been supplied of late years from the East via Fort Wingate. Allowing half as much more for this garrison, and we have an annual total of about 942,000 pounds. At the present very reasonable rates of freight on this contract, a saving of 100 miles of distance would result in an economy of $7,573 per annum. Besides this, an allowance should be made for the stores shipped for the use of the agency at Fort Defiance. These are brought over the same route, and, although they probably are not of great weight or value, they should be considered. I am unable to report the exact figures, not having access to the proper sources of information. The appropriation for the support of this particular tribe, last reported, was over $80,000.

The fact that stores are shipped to Camp Apache from the East now shows that every extension of the Colorado Railroad system, and every improvement in connecting roads, will lessen the expenses of the military service in Arizona by extending the perimeter which can be supplied from the East as cheaply as from the West. The unlikelihood of railroad enterprise in Arizona from the Pacific side makes it the more incumbent to stimulate advances from the East.

A secondary consideration should here be considered. The San Juan mining district, occupying the mountains at the head of the Rio Grande and almost exclusively on the Pacific slope, has been growing in importance, and has been filling up with the usual class of population. Although the mining operations are now conducted on lands ceded by the Ute Indians, experience shows that there will be no hesitation in extending their prospecting on to lands belonging to the Indians, and exciting thereby their dissatisfaction, if the miners should so desire. In that case, a military force would be called for at once, and the probable result would be that a permanent post to the west of Fort Garland and looking upon the mines would be established. One of the present routes to the San Juan country is up the Rio Grande, and making the pass at the head of that stream. This pass is 12,370 feet high, or nearly 3,000 feet higher than the Sangre de Cristo Pass. The other pass is via Saguache and the Lake Fork of the Gunnison River, crossing the divide to the head of the Animas River at an elevation of 12,150 feet.

From the fact of the high altitude of these passes, the snow lies deep and long into the spring. From the reconnaissance made under my directions in the spring of 1873, it was reported that on the 9th of June, in crossing this divide at the head of the Rio Grande, nearly 3 miles lay "over and sometimes through continuous sheets of snow, in many places of great but unknown depth, generally, however, from 4 to 8 feet." On the 25th of June, on the pass from the Animas River to the Lake Fork, the report says, "There was much very deep snow, which fortunately bore the animals and bridged many gorges which would make the pass nearly impracticable without the snow." This remark, applying only to pack-animals, was verified during the summer of 1874 by Captain McCleave, Eighth Cavalry, who was compelled to take pack-animals in making the trip to the mining regions by this road. By passing to the mines by the lower route, crossing the Chama spur by the proposed wagon-road, the Atlantic and Pacific divide is crossed at an elevation of only 7,600 feet, and the outlying hills are nowhere reported over 8,000 feet. The Animas River is reached at the elevation of 6,410 feet, and, following up that stream, the road nowhere exceeds 10,500 feet in altitude, and the elevation of Baker's Park itself is 9,600. A route averaging 3,000 feet less in altitude must be equivalent to a month or six weeks' additional time in the spring, and this fact may well be considered in the formation of an opinion on its desirability. This lower

road can be and is used by crossing the Rio Grande at Cieniguilla and thence by Abiquiu or El Rito to Tierra Amarilla, but the detour for military purposes from Fort Garland would amount to fully 60 miles.

The following tables give the various distances from the present termini of the railroads to Fort Wingate by different routes, and the distances from the probable termini of the railroads on the 1st of July next:

By proposed route:

	Distance between intermediate station.	Distance from Pueblo.
Pueblo to Fort Garland	81.14	81.14
Initial point of survey	38.00	119.14
Crossing of Rio Chama	63.98	183.12
Puerco Station	83.06	266.18
Fort Wingate	102.41	368.59

Fort Wingate to West Las Animas:

Via Fort Union, (tables of chief quartermaster Department of Missouri)	474
Via Trinidad and Fort Union	486
Via Santa Fé and Fort Garland	488
Via Lieutenant Morrison's route of 1872	504
Via proposed route	448

Fort Wingate to Pueblo:

Via Trinidad and Fort Union	476
Via Fort Garland and Santa Fé	408
Via Lieutenant Morrison's route of 1872	424
Via proposed route	369

Fort Wingate to Cucharas station:

Via Fort Union	424
Via proposed route	347

Fort Wingate to Trinidad:

Via Fort Union	385
Via Costilla and proposed route	339

Santa Fé to Cucharas station:

Via Fort Union	254
Via Fort Garland and Taos	210

Santa Fé to Pueblo:

Via Fort Union	305
Via Taos	232

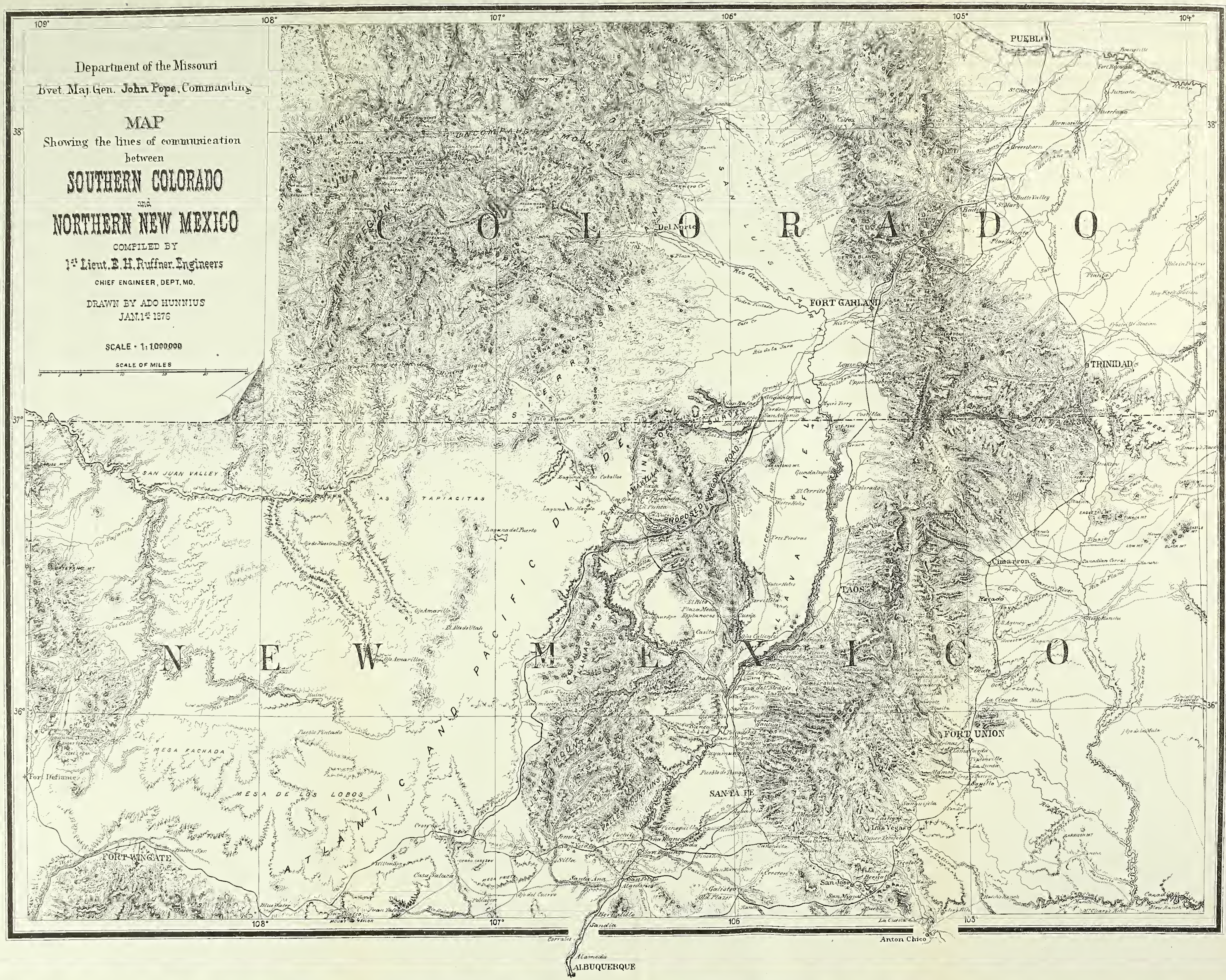
Santa Fé to Cucharas station, via Taos and Fort Garland	210
Santa Fé to Trinidad, via Fort Union	215

Saving in distance by proposed route over present shortest routes of wagon-transportation between Fort Wingate and West Las Animas ... miles	26
Pueblo ... miles	105
Cucharas station compared with present railroad terminus ... miles	125

Probable saving in distance July 1, 1876, in wagon-transportation between railroad terminus at Cucharas and Santa Fé, by Abeyta Pass and Taos, over present distance from West Las Animas to Santa Fé, 90 miles.

Probable saving in distance for light or spring-wagon transportation between railroad terminus at Cucharas and Santa Fé, via Abeyta Pass, over present, via Trinidad and Fort Union, 108 miles.

Supposing the railroad termini to be at Trinidad and Cucharas respectively, the saving in distance from Fort Wingate to Cucharas station, via proposed route, over that to Trinidad, via Fort Union, is 38 miles.


Department of the Missouri
Bvet. Maj. Gen. John Pope, Commanding
MAP
Showing the lines of communication
between
SOUTHERN COLORADO
and
NORTHERN NEW MEXICO
COMPILED BY
1st Lieut. E. H. Ruffner, Engineers
CHIEF ENGINEER, DEPT. MO.
DRAWN BY ADO HUNNIUS
JAN. 1st 1876
SCALE • 1:1,000000
SCALE OF MILES
109°
108°
107°
106°
105°
104°
38°
37°
36°
COLORADO
NEW MEXICO
PUEBLO
Del Norte
FORT GARLAND
TRINIDAD
Rio Grande
SAN JUAN VALLEY
LAS TAPIAGITAS
UNCOMPAHGRE MOUNTAINS
SIERRA SAN JUAN
SIERRA BLANCA
PROPOSED WAGON ROAD
Cimarron
TAOS
FORT UNION
SANTA FE
Las Vegas
San Jose
San Miguel
ATLANTIC AND PACIFIC
MESA FACHADA
MESA DE LOS LOBOS
Fort Defiance
FORT WINGATE
Santa Ana
Bernalillo
Sandia
Corrales
Alameda
ALBUQUERQUE
Anton Chico
Galisteo
Old Placer
Cubero
Laguna del Puerto
Ojo Amarillo
El Alto de Utah
Pueblo Pintado
Rayado
Mora
La Junta
Tecolote

With Pueblo as the terminus of competing roads, freight-rates will be as reasonable there as at West Las Animas, and we can sum up the probable advantages of the constructions recommended as follows:

In case of the opening of a wagon-road from Conejos to the Rio Chama, the saving in distance by wagon to Western New Mexico and Arizona will be from 26 to 105 miles over present and immediately prospective facilities. In case the additional incentive to railroad extension to the west be sufficient to induce the railroad companies to build into the valley of the Rio Grande, the saving will be as much more.

In case of the improvement of the road from Fort Garland to Taos, the entire Southern New Mexico trade will be benefited in the saving of from 40 to 80 miles.

In view of the facts herein described, I am of the opinion that an improvement of the two lines of road from Fort Garland to Taos, and from Fort Garland to the Chama River, is desirable; and that the interest of the military service would be justified in asking for an appropriation for this purpose.

I therefore respectfully recommend that an appropriation of $10,000 be requested to improve the "military road from Fort Garland to Santa Fé, N. Mex.," and that an appropriation of $30,000 be requested to open a "military road from Fort Garland to Fort Wingate, N. Mex., by the shortest practicable route."

I submit herewith a map, showing the lines of communication described in this report and the proposed new road. I also submit an atlas of detail-sheets of the survey of the road in question, and would state that were the appropriation requested obtained, work could be immediately commenced, and the road probably would or could be in use by the middle of September of this year.

I invite attention to the report of Lieut. G. S. Anderson, Sixth Cavalry, appended, and to the general tables of distances and descriptions, compiled from the notes of the survey.

I am, very respectfully, your obedient servant,

E. H. RUFFNER.
First Lieutenant Engineers.

FORT LEAVENWORTH, KANS., *July* 25, 1874.

SIR: I have the honor to submit the following report of an expedition, while under my direction, for the survey of a wagon-road from Fort Garland, Colo., to Fort Wingate, N. Mex.

By the letter of May 13, 1874, from the assistant adjutant-general Department of the Missouri, I was directed to take charge of an expedition "engaged in examining the practicability of building a wagon-road in a direct line from Fort Garland, Colo., to Fort Wingate, N. Mex.," and the following was given me as a "schedule of route:"

"Fort Garland to Rio Grande at most convenient crossing both for road and river.

"Leave Rio Grande, going up the Conejos and across the divide to the headwaters of the Chama River.

"Down the west side of the Chama to the west of the Jemez Mountains and the divide between the Chama and the Puerco. In this schedule, the important point is the finding of an easily-worked and good-grade passage of the divide between the Rio Grande and the Chama.

"New routes should be shown returning."

By verbal instructions received from yourself, I was made more fully acquainted with the nature and details of the work to be accomplished.

My report will embrace: First, a description of the organization of the party for field-service; secondly, a general account of the instrumental work done; thirdly, a desciption of the physical character of the country passed over; fourthly, a comparison of the two routes over which lines were run, with reference to their practicability for purposes of a road; fifthly, recommendations and estimates. The report is accompanied by an appendix, which contains a tabular statement of the distances from

camp to camp, and the latitudes and departures, obtained by stadia-theodolite and other information.

The party was organized as follows: An assistant was placed in charge of the stadia, and recorded the azimuths of the various courses; a recorder was charged with the reading of the rods and with the topography; an escort of one corporal and seven men was employed in bearing the rods and doing the fatigue-work of the expedition.

Assistant D. W. Campbell and Recorder Samuel Anstey reported to me at Fort Lyon, Colo., on the evening of May 27; on May 28 I arranged my detail and prepared for starting, but was detained until the 30th by an exceptionally severe rain-storm, which lasted three days, and swelled the Arkansas River beyond its ordinary high-water mark, and rendered the road almost impassable.

The bridge across the Arkansas at Las Animas being burned, I was obliged to go by way of Pueblo to obtain a crossing. I reached Pueblo on June 2, and Fort Garland on June 5, and at once proceeded to the organization of my party for the field. Assistant Campbell and Recorder Anstey were charged respectively with the instrumental work and with the topography. Corporal Sickles, M Company, Sixth Cavalry, was given charge of the pack-train and the fatigue-labor of the expedition. Private Tomson, G Company, Third Infantry, and Private G. W. Brown, M Company, Sixth Cavalry, carried the rods. I devoted my time to reconnaissance work, and rode ahead each day to determine a line and a camp for the day succeeding.

The instrumental work performed consists of a line run from an established point on the land-survey, (about 100 yards south of the convent at Conejos, Colo.,) via the Conejos and Los Pinos Rivers, and the west branch of the Chama to Tierra Amarilla; thence across the Chama and the heads of the Gallinas and Capulin Creeks to the divide at the head of the Puerco. On our return, a second line was run from Tierra Amarilla to our point of departure at Conejos, via the Nutritas Creek and the heads of Vallacita and Petaca Creeks, and the west branch of the San Antonio.

Our point of departure was 13 chains west of section corner between 19 and 20, of township 33 north, of range 9 east, of N. M. meridian. The instrument used was a stadia-theodolite, made by Aloe, of Saint Louis, 5-inch horizontal limb, with two verniers reading to 20″; telescope. 8½ inches focal length, 1⅛-inch aperture. The vertical limb read by a vernier to single minutes. The New York leveling-rod, with double targets, was used, and was read by the topographer, or, in his absence, by the rod-man. The lower target was clamped at the "1-foot mark" in order that it might be seen in grass or low bushes, and 1 foot was afterward deducted from each reading; to prevent this target from interfering with the sliding of the rods, a piece of wood was inserted underneath the back part of the rod, on which the sliding-portion rested when down; a similar piece filled the interval in front and above. A rod made especially for the stadia, with graduations commencing at some distance from the bottom, would be found very useful in underbrush and over a rolling country. Horizontal distances were determined entirely by stadia readings, and the course was kept by instrumental azimuths taken by back-sights and fore-sights at each station, and by magnetic readings. Observations for meridians were made nightly, as far as the weather would permit, on Polaris.

On June 9 I left Fort Garland and marched in a southerly direction along the road toward Culebra, taking this route because the Rio Grande was not fordable and could only be crossed at Meyer's Ferry, near Costilla.

Owing to the inexperience of my escort as packers, and their need of further instruction, I only traveled about 2 miles the first day, and made camp on the Trinchera, whence I could take an early start the succeeding morning, with the packing performed under the direction of a practiced packer detailed for my assistance from the fort. I was provided with ten pack-mules and five saddle-mules, four of which latter were ridden by the instrumental party, and the fifth by the corporal. I had with me for my own use my horse, brought from Fort Lyon.

About 8 miles from Fort Garland we passed around the east of a point of low hill called Piñon Point. The adjacent country is nearly level and the road a good and perfectly well-defined one. On the Trinchera there was water and wood in abundance, but stock-herds are becoming so numerous in the country that grazing cannot at all times be depended on. The route from this camp to our next (the No. 8 of the expedition) was across the southeast corner of the so-called San Luis Park, but the natural features of the country are rather those of a desert. Nothing but sage-brush grows on this barren, except on the low hills which in some places dot it, where are seen a few stunted piñons and cedars.

We passed the town of San Luis, and made our next camp about 4 miles below it, on the south bank of the Culebra, near the plaza San Acacia. San Luis is a flourishing-looking Mexican town, 16 miles from Fort Garland, and is the largest of the series bearing the general name Culebra; it contains about one hundred houses, and has a post-office, which, by the way, is also called Culebra. The creek is thinly timbered with cottonwood and bordered with an undergrowth of willows; at this time it was so high as to be unfordable, but was passed by a bridge at San Luis; ordinarily it is

readily passable at almost any point. From camp No. 9 we passed down the valley of the Culebra about 10 miles, and then rose the bluff to the second terrace, which we found to be a sand-plain, similar in character to the other portions of the San Luis desert. After 10 miles of a journey over heavy sand, we reached the Rio Grande, but were unable to cross before the following day, owing to the stormy wind prevailing during the afternoon of our arrival there. The ferry-boat is a dilapidated affair, and it was with considerable difficulty that we were enabled to cross by it at all. Should no other means of crossing the river be provided, it will be practically impassable for teams during at least two months of each spring. At this point there was neither wood nor grass near the river.

On June 10 we crossed the river, but were occupied until noon in the passage; we then marched to a camp on the San Antonio near its junction with the Conejos, and about 10 miles from the ferry. Our route as far as the San Antonio lay between lofty hills of a sandstone and lava formation; beyond this we were obliged to follow down the creek to obtain a crossing, as the bridge which once existed here had been swept away.

The valley of the Conejos, which we ascended next day as far as the plaza of Guadaloupe, is apparently very fertile, and good crops of cereals and grass are grown; it is well timbered near the banks of the stream by the bitter cottonwood, with the usual accompaniments of willow and alder. The crossing of the San Antonio was difficult, but the crossing of the Conejos would have been found impossible had it been desirable to cross it. The river (Conejos) had formerly been crossed by a bridge near the plaza of Guadaloupe, but this was swept away, a few days before my arrival, by the high water.

The march on the 13th from the San Antonio crossing to Conejos was about 10 miles, and we were early in camp. The afternoon was occupied in finding a land-survey corner from which to begin our line, and in the determination of our instrumental co-efficients.

The plazas of Conejos are named Guadaloupe, Los Pinos, Ciseneroz, San Raphael, San Antonio, Cerritos, Islan, Rincones, and Cordon, the first being the largest, and contains the post-office; taken together they comprise a very flourishing Mexican settlement of near 300 houses.

On June 14 we commenced work, and ran our lines up the valley of the Conejos about 7 miles and made camp; our road thus far was a good and well-defined one, leading past the plaza of San Raphael and a couple of deserted settlements; the valley seemed very fertile, and was for the most part under cultivation. To the south of this valley—here one-half mile in width—is seen a mesa which rises gradually toward the west until it nears the foot-hills of the mountains, where it is broken by an abrupt descent similar to its northern and southern sides. I climbed this mesa with some difficulty, and found its flat top some 300 or 400 yards wide, covered with bowlders of vesicular lava; the valley bordering it on the south is slightly undulating and apparently without water; it is well grown with rank bunch-grass and thickly timbered about its edges with pine, spruce, and cedar. The north slope of the mesa exhibited strata of soft, gray, friable sandstone, alternating with conglomerate.

To the north of Conejos Valley is a similar formation, except as to its top, which, instead of being level and mesa-like, is terminated in two conical peaks, which project 200 or 300 feet above the vertical side-walls.

Next day we followed the beautiful valley of the Conejos for about 2 miles, and then turned to the hills on its southern bank. These we found for the most part covered with a heavy growth of pine, spruce, and aspen; but along the line of our road the country was open for a farther distance of about 2½ miles and well grown with bunch-grass. The Conejos emerges from a narrow and precipitous cañon, whose sides are composed mostly of basalt and vesicular lava, at a point some 2 miles above where we left its banks. It is here a large and rapid stream, passing over a very rocky bed; its shores are lined with a dense growth of cottonwood and an occasional large pine and cedar. We made some 6 miles this day, and went into camp in a heavy pine forest near a small stream flowing into the Conejos. Our line continued up this stream nearly 2 miles, then turned to the north and followed a tributary to its source, and passed over a low divide to the headwaters of a branch of the Los Pinos Creek. A much better road could be built over the first 2 miles from our camp by following the edge of the hill on the north bank of the stream we first ascended; it was impracticable to run an instrumental line there, owing to the dense entanglement of fallen pines and the thick growth of small aspens, about 12 feet high, which had sprung up over the ground.

Our camp was made in a beautiful open valley at the foot of a high mesa, whose sides were still covered with snow. This valley is divided by a low ridge, from the north side of which the water flows in an easterly direction into the Conejos, while the water rising to the south of it flows south into the Los Pinos, about 3 miles distant; his valley was marshy from the melting of the snows above it, and contained several mall lakes of beautiful clear water. Bunch and marsh grasses were abundant, and he country seemed well adapted for a summer range for herds of cattle and sheep. Our

mules sank into the marsh above the fetlocks, and I found travel disagreeable, and, as I at first thought, dangerous; but I soon discovered that there was a hard stratum some 4 or 5 inches below the surface through which there was no fear of penetrating.

In the evening, in company with Mr. Anstey, I walked to the south along a divide for 2 or 3 miles and reached a point on the cañon of the Los Pinos of perfect grandeur; the southern face of the cañon has but a slight inclination, while the northern one on which we stood was rather overhanging.

The water here rushed in a perfect torrent 1,200 or 1,500 feet beneath us, between masses of a highly feldspathic granite.

Down this cañon could be seen the distant peak of the San Antonio Mountain, while on its northern bank, and but a mile or two from us, rose jagged peaks to the height of 2,000 feet. On either bank of the Los Pinos River was a range of high mountains showing ledges of volcanic and metamorphic rock; these mountains were covered with a heavy growth of pine, spruce, and aspen timber, which in many places had been killed by forest-fires, and their blackened trunks either stood tall and dark against the horizon, or in a fallen position helped form (with the thrifty undergrowth of aspen) an impenetrable entanglement.

The valley of the Los Pinos and the valleys of all its tributaries were covered with a most luxurious growth of bunch-grass, which at this season of the year would support large herds of stock, but the immense snow-fields still remaining in the ravines bespeak a severe winter.

From Camp No. 15 we crossed a level space more than half a mile in width, and there commenced the descent of a long and somewhat steep hill, at the bottom of which ran a small but very rapid stream; this passed, we found ourselves confronted by a high "hog-back," which it was necessary to cross, and the ascent and descent of which were both very difficult; from the foot of the descent we carried the line over the hill again, and up the north bank of the creek. In making a reconnaissance later in the evening, in company with Mr. Antsey, I discovered that a better road could be made by following down this second small stream to near its mouth, and there crossing it; the road should cross the main creek near this point, and follow up its south bank, which is throughout less steep than the northern one.

After leaving Camp 16, we followed the Los Pinos about a mile and crossed it. We then followed one of its tributaries to its source, which was on the Chama divide.

Where we crossed the Los Pinos it is a stream 3½ feet deep and about 50 feet wide, with a very swift current. It was probably at its highest stage when we saw it, as the snow still lay almost in mass about its headwaters.

Our camp, No. 17, was near a beautiful little lake about an acre in extent, almost hidden by immense pine-trees, and surrounded by high snow-banks. On account of our altitude, the nights were becoming very cool, and on the 19th day of June we found a thick crust of ice on our water-bucket at sunrise. The snow-banks, which had given us trouble as we were coming into camp, were so frozen as to allow our train to pass without difficulty next day.

I made a long detour on horseback, to the north of the line between Camps Nos. 16 and 17, to see if a practicable route could not be opened in that direction which would avoid the difficult hills we had met the day previous; but I found the country of the same rugged character as that we had passed, and it became more abrupt and snow-bound the farther north I proceeded. I am satisfied that no practicable road can be made to the north side of our line, as it was with great difficulty that I was enabled to get my horse over it, and for a greater part of the way I was forced to dismount and lead him.

The divide at Camp 17 was very low on the side of the Los Pinos, but the descent to the Chama was quite abrupt. At this point the valley of the Chama is at least 2 miles wide, and supports a more luxuriant vegetation than any we had yet seen. For about 3 miles from the point at which we entered it we found very heavy timber, some of the pines measuring more than 4 feet in diameter and 200 in height. Below this the valley is open and thickly covered with a heavy growth of bunch-grass. Wild flowers were found in great profusion and beauty. The valley is inclosed on the north by a range of knife-edge hills, back of which this branch of the Chama rises. Their southern faces are composed of a soft, white, disintegrated material, probably lime or feldspar. At the foot of the highest peak is a beautiful little park of about 50 acres extent, containing a small lake of clear water. The south bank rises gradually into the high Chama Mountains, which are timbered to their summits with heavy pines.

About 4 miles from Camp 18 we crossed the river, but only with considerable difficulty. The banks are about 50 feet high, and very steep, and the stream very rapid. A short distance below this point the Chama receives a large tributary from the west, up the valley of which the snow-covered Navajoe range is visible. The remainder of the valley between this point and our Camp 21, at Los Ojos, is very much like that part of it we had already passed, except that the west bank assumed a mesa-like appearance, and heavy timber, with an undergrowth of scrub-oak, continues down the mountain to the river's edge. Several small streams, running through deep and narrow ravines,

must be crossed, but there is an abundance of material at hand, with which they may easily be bridged. The west bank of the river is close under the mesa-wall, and offers no site for a road.

The Tierra Amarilla includes five Mexican plazas, named Nutritas, Ensenada, Los Ojos, Los Brazos, and La Puenta. The general name is borne by a section of country near old Fort Lowell, which, under irrigation, produces fair crops of corn and cereals, but stock-raising is the principal industry of the inhabitants. Near the plaza Los Brazos the Chama is formed by what are known as the east and west branches, the former of which rises about a mile south of our Camp 17, and debouches from the Chama range through a very precipitous cañon. The river here is about 80 feet wide, with an average depth of 3 feet, and a very swift current, making the fords at this season of the year very difficult. In ordinary stages of water they offer no obstacle to an easy passage of trains.

From Tierra Amarilla we missed our direction, and ran our line for the first day along the Santa Fé road to the crossing of the Nutrias; to the east of the road runs a high sandstone and conglomerate cliff, forming a divide between the Nutrias and the Nutritas Creeks; to the east is a series of low hills, covered with pine, piñon, and cedar, between which stretch broad plains, producing a heavy growth of sage-brush. Farther up on the side of the mountain are immense fields of scrub-oak and aspen.

From Camp 21 we descended the Nutrias, whose valley for the most part contains indifferent grazing, but very thrifty sage-bush.

The whole of the valley, as far as Camp 22, is composed of a loose drift; here the stream enters a box-cañon with soft sandstone walls, the stratification of which is nearly horizontal.

Two routes here presented themselves, the one crossing the Chama about a mile below the mouth of the Nutrias, and the other about 3 miles above it. Owing to the apparent impracticability of the lower ford, I concluded to cross at the upper one, and accordingly ordered my party to take that direction, and, after crossing, to follow down the valley to the west of the Gallinas Mountains, while I rode on to Fort Wingate to obtain rations and supplies necessary for my escort. I met with some difficulty in getting down the river through a system of narrow and intricate cañons, and when on its banks found it no easy matter to pass the stream in its then high stage.

I did not anticipate that there would be any difficulty in crossing the pack-train at the regular ford, but on my return to the party I learned that one animal had been swept away by the current and only saved with extreme risk to the men, and that two days had been spent in the passage. The river was 3½ feet deep, with rocky or gravelly bottom, but at the ford the gravel gave way and developed a dangerous quicksand underneath. It is probable, however, that this was in some way due to the high state of the water, as teams have passed here without difficulty for years.

While packing the train, previous to leaving the camp on the west bank of the Chama, Private John Dougherty, F Company, Third Infantry, was instantly killed by the accidental discharge of a carbine, which had carelessly been left loaded after a hunt the previous evening. He was buried on the west bank of the Chama, at the foot of a high mesa near the lower crossing; his grave was piled with stones to protect it from the wild animals, and its head marked by a rude cross.

After leaving the Chama we passed down a trail made by Major Price, Eighth Cavalry, in the summer of 1872. The road at first ascends an arroya, skirting the base of the Gallinas Mountains; then rises a low divide some 10 miles distant from the lower ford. The country near the river is furrowed by numerous deep gullies, and produces little else but sage-brush and cactus. At the divide we entered a valley some 35 miles in length and from 3 to 12 miles in width. This valley is bordered on the east by a range of mounts, through which two small streams, the Gallinas and the Copulin, find their way to the Chama. The north end of the range is called Gallinas, the middle section Copulin, and the south end Jemez. They are all covered with evergreens and aspens to their summits, and their more abrupt faces show strata of various-colored sandstone. Near the plaza of Nacimiento the Jemez Mountains sent far into the valley spurs of low hills, covered with heavy pine and spruce timber. Between these hills are grass-grown meadows, traversed by clear mountain streams, bordered with willows. The first of these streams is the Puerco, which, after reaching the main valley, turns to the south and receives the others as tributaries.

The west of this valley is shut in by a range of sandstone mesas from 100 to 500 feet high, showing, in their vertical sides, shales, conglomerates, clays, and various colored strata of friable sandstone. This formation extends down the west bank of the Chama to old Fort Lowell from a point some 20 miles above it; near that fort it leaves the river and follows down to the west of the Puerco as far as the stage-road crossing, where it apparently ends. Its southern face is seen to the north of the road over its whole length to Fort Wingate. This valley is traversed longitudinally, from its northern extremity to the head of the Puerco, by one principal range, a number of smaller ranges of knife-edge hills of peculiar appearance sometimes rising to a height

of 300 feet. They are formed of a soft, light-gray sandstone, with strata having a dip to westward of near 45°.

The west face has a thin covering of soil, supporting a growth of evergreens; the east face is nearly vertical, showing the edges of the strata; the bottom is filled with *débris.*

These ranges are in several places broken through by streams which take their rise at the foot of the mesas on the west, and find their way to the Chama. At the time of our passage they were dry, and to all appearances their principal use was to carry off surface-water. The remainder of the valley is gently rolling. The lower hills are covered with evergreens, and the level spaces between them with a rank growth of sage-brush. The flies were so numerous about these small creeks that we were obliged to go into camp nearly a mile from water, and send down our kegs for a night's supply. Many pieces of both painted and unpainted pottery and some stone arrow-heads were found on mounds of drift, among fragments of quartz and petrified wood, but none were to be seen on the higher hills, nor were they to be found in any numbers on the level plain. Near Nacimiento were several large meadows, supporting fine herds of stock; but little of the ground was under cultivation.

I left my party at the crossing of the Chama on June 25, and reached the mail-station on the Puerco, distant near 100 miles, next day at 11 a. m. I here took the buck-board and rode to Fort Wingate, where I remained two days, and drew supplies for my escort. I took my supplies with me as far as the Puerco on the buck-board. Here a pack-mule was in waiting to carry them to camp, which was then near the head of the Puerco, some 35 or 40 miles distant. I reached my camp on July 1, and next day retraced my steps toward Tierra Amarilla, which place was arrived at by my party on July 4. From this point I desired to make a horse-back reconnaissance of a trail leading to Conejos by way of the east fork of the Chama, but my own horse was too much exhausted to undertake the journey, and I was unable to procure a fresh one. I learned, however, from reliable sources that the trail passing this way, though direct and easily passable for animals, could not be made into a wagon-road on account of the numerous steep hills it crosses and the many rocky ledges over which it leads.

On July 5 we commenced our second line, which connects with our first near the plaza of Las Nutritas, and ran it up the Nutritas about 6 miles. This stream we found timbered with evergreens for about 5 miles, when it opens out into a broad expanse covered with scrub-oak. This plane is terminated on the south by an abrupt cliff, disclosing a few badly-preserved cretaceous fossils. The summit of this cliff is the divide between the Nutrias and the Nutritas, and from its highest points a most magnificent view of both valleys and the mesas beyond the Chama is obtained. We found the ascent of the Nutrias gradual and easy, and met with no difficulty until we neared its source, where we entered a heavy forest of pine and aspen, which furnished a serious obstacle to the running of our line.

Camp No. 32 was made on the summit of the Chama range, at the foot of a very high conical peak, composed mostly of lava, trachyte, and pumice. Many beautiful varieties of flowers, among them the columbine, wild tulip, and a brilliant-yellow lily, were found here growing at the very edge of the not yet melted snow-banks. Our course now lay down the Vallicita some 5 or 6 miles, between ranges of low pine-clad hills. This valley is in some places narrow and closed by heavy timber, but through most of its length is open and covered with rank grasses. We left the main stream at a point where it receives a tributary from the north and another from the east, and turns directly to the south through a rocky gorge. The line here passes over a point of metamorphic rock, and ascends the narrow ravine of the eastward branch to an open meadow near its source. This meadow is surrounded by low hills covered with pines and aspens, in the shadows of which banks of snow were still remaining. The small stream which takes its rise here alternately expands into pools several yards wide and contracts to the merest thread of a channel, almost concealed by its grassy banks, meanwhile retaining a depth of a couple of feet or more, and disclosing through its crystal waters a sparkling schistose bottom. The whole region about the headwaters of the Vallicita is broken by bold outcroppings of schistose rock and highly feldsphatic granite. After leaving Camp 33, we descended a branch of what is known at its source as Las Tusas Creek, but what is known farther down as Petaca. The first mile of our descent was rendered difficult by a dense undergrowth of aspens, and by the marshy condition of the ground, occasioned by the melting snow-banks, the last of which in our course we here passed. Below this thicket the valley opens out into a most fertile pasturage, bordered by timbered hills. The clear stream traversing it is filled with brook-trout. In the evening a large cinnamon bear passed by our camp and entered the woods near it, where he was unsuccessfully pursued by a party of my men.

From Camp 34 we ascended a small branch of the Petaca for about a mile, and then passed over a low divide in an easterly direction to a second branch, which we followed to its source. All this country is gently rolling, and its valleys furnish good grazing to numerous sheep herds. The highest parts are well timbered with pine, spruce, and cedar, and the banks of the small streams are lined with willows.

To the west of us rose the high snow-crowned mountains we had just crossed, while in our front appeared a mesa towering some 3,000 feet above us. An occasional face of sandstone with horizontal stratification was seen, but most of the country is covered with small bowlders of dark vesicular lava. This formation extends as far as Camp 35, near the headwaters of a small branch of the San Antonio, called Nutritas Creek. The high plain between the Nutritas and the cañon at the head of the Petaca is about 4 miles in length by 3 in width, and is dotted with small patches of heavy timber. It is inclosed by the lofty mesa on the east and the still higher mountains on the west, and affords good pasturage to large stock herds.

The Petaca Cañon, through which we passed, is nearly one-half mile in length and from 20 to 150 feet deep. It is very narrow, and its bottom is strewn with lava bowlders.

Near the Nutritas we entered an arroya grown with huge pines; this we followed down to the creek, where we made camp in a valley beautifully supplied with fine grass. Next day we followed this creek down about 4 miles to its mouth, and ascended a steep hill leading to another volcanic mesa, supporting an occasional pine and but little grass. At the foot of this mesa, on the east, lay the plaza of San Antonio, on the creek of the same name. Here I was obliged to employ a wagon to convey to Fort Garland one of the members of my escort, who had been very ill for several days with dysentery. At Los Pinos we again entered a level and cultivated country; cottonwood trees lined the creek, giving its valley, as seen from the mesa above, an appearance of thrift.

On July 12 we finished our line at the point of beginning, and made camp on the San Antonio River, near its junction with the Conejos. The valley here is very low, and in many places was still wet and boggy. On our arrival here, a month previous, it was entirely submerged. Our route now continued along the Conejos to its mouth. For a greater part of its length, this stream flows through several channels, forming a great number of small islands, most of which are covered with good grass and thrifty cottonwoods. Beyond these islands the country does not differ from the remainder of the San Luis desert in any respect.

In the angle formed by the Conejos and the Rio Grande runs a broken range of abrupt hills and mesas, terminating on the south in the San Antonio Mountain, which is an immense conical peak, rising some 3,500 feet above the general level of the country. It was along this route, and but a few miles from the Rio Grande, that Lieutenant Pike was captured by the Mexicans in the early part of the present century, and taken to Mexico.

Owing to our having taken a wrong road, the Rio Grande was reached at a point some 3 miles above the ford. Here the meadows on its banks were covered with large pools of water, on which floated hundreds of young ducks and water-fowl; the mosquitoes were so numerous as to be hardly bearable, and gave us more annoyance than they had given us at any previous time on our journey.

The Rio Grande was much lower than when we crossed it before, but still was not down to its summer level. We lightened the packs on our animals and crossed in a very short time without accident, although the water nearly covered the backs of the smaller mules. We followed the valley of the Trinchera direct to Fort Garland, where we arrived on July 15. I at once turned over my quartermaster's property, and made application for transportation to Fort Lyon. Next day I was furnished a wagon in which I dispatched my escort, but I was obliged to remain over another day before an ambulance could be placed at my disposal. This same evening I received a copy of a telegram from the assistant adjutant-general Department of Missouri, directing me to return my assistants to Fort Leavenworth at once. I left Fort Garland on July 17, and traveled by the Sangre de Cristo Pass and the Huerfano and Arkansas Valleys to Fort Lyon, which point I reached on the 20th.

I here disbanded my party, the members of the escort returning to their companies, and my assistants to Fort Leavenworth, as directed. In obedience to a telegraphic order of the 21st instant, I left Fort Lyon on the 23d, and arrived on the 24th.

COMPARISON OF ROUTES.

Between Fort Garland and Conejos two routes present themselves; the one by Culebra and Meyer's Ferry is about 10 miles the longer, and has a very sandy stretch of 8 or 10 miles, over which travel will be tedious and difficult. This route presents the further objection of not being so well supplied with wood and grass.

In the one case the Conejos, and in the other the San Antonio, must be passed, and to insure a crossing at all seasons of the year a bridge would be necessary over either. There was a bridge over the Conejos at Guadaloupe, but last spring's freshets carried it away; several of the most responsible citizens of the place informed me that it would in all probability be rebuilt.

The Rio Grande is unfordable for about two months of each year, and there is bu little choice in this respect between the two fords. If the river is to be bridged, it

may as easily be done at the one place as at the other. The road by way of the Trinchera is hard and level, and in every respect a good passage-way.

From Guadalonpe, by our first line, the road is a good one as long as it remains in the valley of the Conejos ; after leaving this valley it rises a hill, on which some work will be required for nearly a mile. The principal labor will consist in removing the surface-stones and leveling the side-slopes. This, I think, can be accomplished by 150 days' work. Some timber would have to be cut on the top of the hill, and a little grading down on the descent, but a few days' labor will complete it all. The crossing of the creek near Camp 14 would be materially improved by a small bridge, which might be readily constructed from timber found on the spot. Beyond this point the way must be cleared for about two miles, of fallen timber and underbrush, for which I would estimate 200 days' work. The next difficulty is between Camps 15 and 16, where the route is at first level and marshy, and afterward passes over a steep hill. I presume the marshy places would give little or no trouble after they had been passed over a few times by wagons, as the paths were more firm than the untrodden ground.

The descent of the first hill could be made without much difficulty by properly winding the road to take advantage of the lightest grades. A bridge at its foot will be necessary for an easy crossing of the creek. The passage of the hill beyond this point can only be made good by continuous grading for nearly a mile; this will require 500 or 600 days' work. The hill is very steep on both slopes, and in some places will give a grade of at least 1 foot in 8. At the bottom of its western slope, about 300 yards of road must be made of stone, along one wall of a narrow gorge, and then carried across a small creek by a bridge; there is at hand, however, plenty of stone and timber for all needs.

Some little siding will require to be made between this point and the head of the Chama, and a bridge or ford must be made across the Los Pinos, and several small bridges across its tributaries; 600 days' work will probably complete this portion of the road.

The descent to the head of the Chama and the passage of the stream at the foot of the hill are the next difficulties to be encountered, except such as may be given by snow. On June 20 there were still large snow-banks on this divide, but none that would obstruct travel on a properly-defined road. The hill here can be passed by a careful grading at about one on nine, and the stream may be easily bridged. The side-hill along which our line next passes is broken by high knolls and deep ravines, most of which may be in great part avoided; some work, however, must be done here in the way of grading, and a number of large trees must be cut. The exact amount of work to be done can only be determined after the road receives a definite location.

A bridge must be built over the Chama, at the crossing below Camp 18, and some work will be required on its steep banks. Between here and the plaza of Las Nutritas, about one-half mile of siding must be made, and some three or four small bridges built over narrow ravines. For a short distance, the way is obstructed with timber, but no difficulty will be experienced in removing it.

In going from Tierra Amarilla to Fort Wingate, three crossings of the Chama are to be chosen between ; the upper one is the plaza of La Puenta, and has recently been washed out at the side, so as to be entirely impassable. The next one in order is about 8 miles farther down the stream, and gave us great trouble on our outward trip by its treacherous bottom. The third is about 4 miles farther still below, and is difficult to reach on account of high bluffs on both sides the stream. I think the middle one will give the best crossing and the most direct road.

The remainder of the route to Fort Wingate has recently been traveled by wagons, and is, without any work, a very good road.

On our return from Tierra Amarilla to Conejos, we found a good route up the Nutritas to near its head, where one-half mile of grading must be done, and on the first divide timber must be cleared for nearly a mile. In the valley of the Vallicita, a few days' work will be necessary on side-hills and at the creek-crossings.

In passing from the Vallicita to the Petaca a narrow cañon is met, up which a road must be constructed of stone, or a detour must be made over a steep hill requiring deep side-cutting. Plenty of material is convenient for the making of this part of the road.

At the head of the Petaca a narrow ravine, filled with a dense growth of small aspens, is met with, and to construct a good passage-way through it will require 200 days' work, or, perhaps, more. The country is open the balance of the way, except for a short distance in a narrow cañon ascending from the Petaca, where a rocky bottom will give some trouble. A good road can be made, however, up either one of two branches, a choice between which must be made after a careful inspection of both.

The descent to the San Antonio only requires the removal of a few fallen trees and the making of a few yards of grade. In rising from the San Antonio to the high mesa, which ends at Los Pinos, a steep hill is met with, up which a grade of 1 in 8 can be obtained. The descent near the plaza of Los Pinos is about 1 in 6, but is not more than 100 yards in length. From here to the plaza of Guadalupe the road is good, level, and direct.

RECOMMENDATION.

From Fort Garland to Conejos, I would recommend the road by way of the Trinchera as being the most direct and in every way the best one. From Conejos to Tierra Amarilla, the second route, the one run on our return, is preferable, in that it is less liable to be closed in winter by snow, and it can be made with easier grades and at less expense. Both routes are supplied with wood, water, and grass in the greatest abundance. The distance by the two lines is about the same, unless the second one be turned down the valley of the Nutrias to the middle ford, in which case it would be a few miles the shorter. Materials for bridges exist in abundance at all points where their use is desirable, except on the Rio Grande, where timber must be carted about twenty miles.

If the road be made by the labor of troops, I think a full company can complete it from Fort Garland to the mail-station on the Puerco in three months. This estimate does not include the building of a bridge over the Rio Grande at the Trinchera, or over either the Conejos, Los Pinos, or Chama. The three latter bridges can be made without great expense.

All of which is respectfully submitted.

GEO. S. ANDERSON,
Second Lieutenant, Sixth Cavalry, in charge of Survey.

Lieut. E. H. RUFFNER, *United States Engineers,*
Chief Engineer Department of the Missouri,
Fort Leavenworth, Kans.

GENERAL TABLE.—*Survey for direct route from Fort Garland, Colo., to Fort Wingate, N. Mex.*

Date.	Stadia distance from Conejos.	Stadia distance from last camp.	Number.	Names.	Latitude.			Longitude.			Soil.	Timber.	Grass.	Water.
					°	′	″	°	′	″				
1874. June 14	......	......	......	Initial point 13 chains west of ¼ sec. corner between secs. 19 and 20, T. 33 N., R. 9 E., of the N. N. E. principal meridian.	37	04	45.154	105	51	52.134	......	......	......	
14	2.400	......	......	Plaza San Rafael......	...	...	......	......	...	......	Near the river the soil is irrigated and cultivated.	Cottonwood along the river; piñon and pine on the bluffs.	......	
14	6.388	......	13	Camp on the Rio Conejos.	37	02	27.058	105	58	07.314	Dry and sandy on the upland.	......	Fair	Good.
15	12.805	6.417	14	......	37	01	58.077	106	04	28.871	Good	Pine, spruce, aspen, a few cedars; willow and cottonwood in the valley.	Good	Do.
16	17.273	4.468	15	......	37	00	59.375	106	08	18.961	....do	......do	Very good	Do.
17	21.633	4.360	16	Camp on the Rio Los Pinos.	36	59	51.095	106	12	20.531	....do.	Pine, spruce, and aspen.	Good......	Do.
18	25.833	4.200	17	On divide at head of the Rio Los Pinos.	37	00	37.601	106	16	40.471	....do	....do	....do	Do.
19	30.496	6.663	13	On the Rio Chama	36	58	32.496	106	20	18.031	....do	Pine, spruce, aspen, willow, and scrub-oak.	Very good	Do.
20	38.441	7.945	19	......	36	53	01.517	106	24	42.441	....do	Pine, spruce, aspen, willow, and scrub-oak; very fine timber.	....do	Do.
21	47.841	9.400	......	Los Brazos......	...	...	......	......	...	......	......	......	......	
22	49.941	11.500	......	Los Ojos	...	...	......	......	...	......	Soil fair; irrigated in some places.	Pine, scrub-oak, cottonwood, aspen, and willow. The pines are very fine.	....do	Do.
22	50.377	11.936	20	Camp near Los Ojos, Tierra Amarilla.	36	43	22.773	106	24	50.463	......	......	Land near camp is mostly cultivated.	Do.
23	51.184	0.807	......	Station No. 248, (point of departure on return route.)	36	42	46.316	106	24	48.591	......	......	......	
23	62.200	11.016	21	Camp on La Nutrias Creek.	36	36	19.233	106	21	36.230	Soil dry and sandy; fair on the banks of La Nutrias Creek.	Pine, piñon, cedar, and scrub-oaks; willow at the camp.	A little grass among the sage-bushes.	Fair.

24	72.165	9.965	22	On La Nutria Creek, at entrance of cañon.	36	35	17.435	106	31	28.314	Indifferent	Sage-brush, piñon, and cedar on the bluffs; willow and box-elder on the banks of the creek.	Poor grazing	Do.
26, 27	76.279	4.114	24, 28	At the lower ford of the Chama.	36	33	48.610	106	34	44.161	....do	Piñon, cedar, and spruce	....do	Good.
July 2, 3	92.301	16.022	27	Camp near Fly Creek.	36	23	16.632	106	41	58.507	Fair	Pine, cedar, piñon, sage-brush.	Good	None.
June 29	101.789	9.488	25	Camp at Marshy Pond	36	16	02.478	106	46	00.822	....do	......do	Indifferent	Very poor.

General table.—*Survey for direct route from Fort Garland, Colo., to Fort Wingate N. Mex.*

Date.	Stadia distance from Station No. 248.	Stadia distance from last camp.	Number.	Names.	Latitude.			Longitude.			Soil.	Timber.	Grass.	Water.
					°	′	″	°	′	″				
1874. July 4	....	....	......	Station No. 248	36	42	46.316	106	24	48.591	....	....	....	
4	1.300	....	29	Near Plaza La Nutria	36	42	04.626	106	23	40.990	Good, (irrigated)	Pine, spruce, and willow	Good, but close cropped by cattle.	Good.
5	1.650	0.350	......	Plaza La Nutria	...	....	....	......	..	....	....	....	....	
5	7.121	6.821	30	La Nutrita Creek	36	38	29.813	106	20	14.567	Good	Pine, aspen, scrub-oak, cottonwood, and willow.	Good	Good.
6	11.002	3.881	31	....	36	38	02.347	106	16	42.534	....do	......do	....do	Do.
7	15.887	4.885	32	Near the divide	36	38	21.814	106	11	51.860	...do	Pine, aspen, willow, and scrub-oak.	....do	Do.
8	24.207	8.320	33	....	36	42	27.894	106	05	19.759	....do	Pine, spruce, aspen, and willow.	....do	Do.
9	28.276	5.069	34	Station No. 141, Las Tuses Creek.	36	43	47.052	106	01	49.281	....do	......do	....do	Do.
10	34.835	6.559	35	On La Nutria Creek	36	48	49.899	106	02	34.856	... do	......do	....do	Do.
11	48.259	13.424	36	On Los Pinos Creek	36	58	36.509	105	55	04.901	Arid	Spruce, pine, aspen, cottonwood, and willow.	Poor	Do.
12	55.641	7.382	......	Initial point of survey	37	04	17.919	105	52	58.804	....do	Cottonwood and willow along the banks of the creek.	....do	Do.

APPENDIX RR.

ANNUAL REPORT OF LIEUTENANT J. C. MALLERY, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1876.

EXPLORATIONS AND SURVEYS IN THE DIVISION OF THE PACIFIC.

ENGINEER OFFICE, MILITARY DIVISION PACIFIC,
San Francisco, Cal., July 5, 1876.

SIR: I have the honor to present my annual report for the year ending June 30, 1876.

The small allotment of funds, merely sufficient for the salary of a draughtsman, has limited the work of the past year.

FIELD-WORK.

In compliance with Special Orders No. 36, Headquarters Department of California, May 5, 1876, I made a survey of the sources of water-supply for Camp Halleck, Nev. The map to accompany the report of this survey is being prepared by the draughtsman. The following are the principal details, viz:

Number of theodolite pointings	374
Number of theodolite readings	748
Number of readings of leveling-rod	451
Total difference of level determined, (feet)	765.5
Number of miles chained	7.513

A line of ditch 2½ miles long, and with uniform grade from the source of water-supply to the reservoir-site, was marked upon the ground. Estimates of the cost of the changes have been prepared.

I. W. Ward, assistant and draughtsman, was directed in Special Orders No. 64, Headquarters Military Division of the Pacific, May 19, 1876, to make a reconnaissance of the trail from Arcata, Cal., to Camp Gaston, Cal. The topography adjacent to the trail for a distance of 40 miles was carefully sketched. The various courses corresponding to compass-bearings have been estimated and checked by the bearings of prominent peaks. A survey of the ground on Redwood Hill, where Maj. J. A. Brodhead, Pay Department, U. S. A., and party were attacked by a highwayman, was also made. A route for a wagon-road from Redwood Creek to Camp Gaston was examined. A map covering the extent of the reconnaissance, and on a scale of 1 inch to 2 miles, is in course of preparation.

The military reservations of Camps McDowell, Verde, and Apache, Arizona, have been surveyed by Lieut. E. D. Thomas, Fifth Cavalry, acting engineer officer Department of Arizona. Plats of these surveys have been made. Lieutenant Thomas has also been engaged in constructing and locating roads in Northern and Central Arizona. The road from Black Cañon to Bowie's Ranch, Agua Frio Valley, was completed in December. The distance by this road from Prescott to Camp McDowell is diminished 18 miles. Its length by chain measurement is 35½ miles.

The road from Camp McDowell to Camp Verde has been improved and made practicable for the heaviest freight teams.

The new road from Prescott to Skull Valley over the Sierra Prieta Mountains was finished in November. This road shortens the route

from Ehrenberg, Wickenberg, and the southern portion of the territory by 19½ miles. Lieut. George Wilson, Twelfth Infantry, made a reconnaissance of the Trinity and Klamath Rivers from Camp Gaston to the Pacific Ocean. Much valuable information concerning the Indian settlements on the Klamath River was collected and incorporated in a very creditable map.

OFFICE-WORK.

Sheets Nos. 1 and 3 map of the Department of Arizona have been revised and redrawn. They have been photo-lithographed in Washington by authority of the Chief of Engineers. Sheet No. 2 has been partly redrawn. Sheets Nos. 4, 5, and 6 have been projected, and are well under way. The draughtsman has been frequently interrupted in this work.

A map of the Department of California, embracing the States of California and Nevada, has been prepared and photographed in this office.

A map of the Military Division of the Pacific, on a scale of $\frac{1}{2500000}$, is in course of projection.

The following is an abstract of the office-work, viz:

Number of maps projected and drawn	9
Number of maps traced	17
Number of photographic prints of maps	597
Number of field-sketches of routes of march	20
Number of plans of buildings	10

A pamphlet, embracing the ordinary methods of determining the true meridian and the magnetic declination, for purposes of military reconnaissance, supplemented with tables of the times of elongation and of the azimuth of Polaris at the different posts of this military division was prepared and distributed to the posts. The receipt of maps of routes referred to a magnetic meridian, either no declination being given or one evidently incorrect, suggested the preparation of this pamphlet. The magnetic declination of the posts, as far as reported, is given below.

Place.	Magnetic variation.	Date.	Authority.
	° ′ ″		
Fort Townsend, Wash	21 59 east	1876, Feb	Capt. G. H. Burton, Twenty-first Inf'ry.
Camp Harney, Ohio	18 23 east	1876, Feb	Lieut. R. P. P. Wainright, First Cav'ry.
Fort Canby, Wash	21 46 56 east	1876	Light-house Keeper Drosley.
Columbia River Entrance	21 38 east	1875	United States Coast Survey.
Fort Lapwai, Wash	19 45 east	1876, May	Lieut. W. M. Miller, First Cavalry.
Sitka, Alaska	28 20 28.8 east	1876*	Capt. J. B. Campbell, Fourth Artillery, and Lieut. W. R. Quinan, Fourth Art.

* The mean of eight observations between January 15 and March 20, 1876.

A compass, with a needle of 4 or 5 inches, and supplied with sights and Jacob's staff mountings, would meet the requirements more satisfactorily than the prismatic compass does. An examination of several of the latter showed a maximum difference of 4 degrees in the bearings of a line. There is reason to believe that more interest and care would be taken by officers in the mapping of their routes of march if instruments of greater accuracy were furnished them.

A list of reports of scouts and of itineraries for the year is appended.

Very respectfully, your obedient servant,

J. C. MALLERY,
First Lieutenant of Engineers.

Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

List of reports of scouts received at engineer office, Military Division of the Pacific, during the fiscal year ending June 30, 1876.

From—	To—	Month.	By whom rendered.	Miles.
Camp McDermit, Nev	Camp Three Forks, Ind. T.	June, 1875	Lieut. C. C. Norton, First Cavalry.	139.10
Do	Winnemucca, Nev	May, 1875	do	157.70
Camp Independence, Cal	Panamint, Cal	June, 1875	Capt. C. C. Carr, First Cavalry.	229.94
Camp Halleck, Nevada	Independence Valley, Nev.	July, 1875	Capt. M. H. Stacey, Twelfth Infantry.	188.66
Camp Independence, Cal.	Calienta, Cal	July, 1875	Capt. A. B. McGowan, Twelfth Infantry.	164.60
Camp Bidwell, Cal	Camp McDermit, Nev	Aug., 1875	Capt. R. F. Bernard, First Cavalry.	405.79
Calienta, Cal	San Diego, Cal	Jan., 1876	do	222.00
San Diego, Cal	San Felipe Valley, Cal	Feb., 1876	Lieut. F. K. Ward, First Cavalry.	144.33
Camp McDermit, Nev	Johnson's Ranch, Oreg	Aug. 1875	First Serg't Otto Wilde, Company C, First Cavalry.	156.00
Do	White Horse Creek, Oreg.	Dec., 1875	Lieut. C. C. Norton, First Cavalry.	102.00
Do		May, 1876	do	66.00
Camp Halleck, Nev	Rubey Valley, Nev	Oct., 1875	Capt. M. H. Stacey, Twelfth Infantry.	106.00
Camp Independence, Cal	Panamint, Cal	July, 1875	Capt. C. C. Carr, First Cavalry.	100.82
Cerro Gordo, Cal	Death Valley, Cal	July, 1875	do	46.00
Do	Hot Springs, Cal	July, 1875	do	58.00
Tennessee Ranch, Cal	Orne's Station, Cal	July, 1875	do	25.12
Camp Independence, Cal	Reno, Nevada	Sept., 1875	do	240.51
Camp Gaston, Cal	Redwood Creek, Cal	Aug., 1875	Capt. Richard Parker, Twelfth Infantry.	35.00
Camp Independence, Cal	Salinas Valley, Cal	Oct., 1875	Lieut. W. W. Wetherspoon, Twelfth Infantry.	90.00
Camp Gaston, Cal	Klamath Bluffs, Cal	July, 1875	Lieut. James Halloran, Twelfth Infantry.	...
Total				2,677.57

List of itineraries received at engineer office, Military Division of the Pacific, during the fiscal year ending June 30, 1876.

No.	From—	To—	By—
1	Angel Island	Camp Bidwell, Cal	Capt. John M. Norvell, Twelfth Infantry.
2	Camp Bidwell, Cal	Reno, Nev	Corporal William Warner, Company G, First Cavalry.
3	do	Camp McDermit, Nev	Capt. R. F. Bernard, First Cavalry.
4	do	Camp Harney, Oreg	Corporal William Warner, Company G, First Cavalry.
5	do	Reno, Nev	Lieut. C. E. S. Wood, Twenty-first Infantry.
6	do	San Francisco, Cal	Capt. R. F. Bernard, First Cavalry.
7	Camp Halleck, Nev	Cleaveland's Ranch, Nev	Lieut. Edward Hunter, First Cavalry.
8	Camp Independence, Cal	Panamint, Cal	Capt. C. C. Carr, First Cavalry.
9	Cerro Gordo, Cal	Death Valley, Cal	Do.
10	do	Hot Springs, Cal	Do.
11	Tennessee Ranch, Cal	Orne's Station, Cal	Do.
12	Camp Independence, Cal	Reno, Nev	Do.
13	Camp Bidwell, Cal	Dalles, Oreg	Capt. Robert Pollock, Twenty-first Infantry.

Table of distances between certain military posts in Arizona, and certain places in Arizona, California, Nevada, and New Mexico.

ENGINEER OFFICE,
MILITARY DIVISION OF THE PACIFIC,
San Francisco, Cal., July 21, 1876.

SIR: I have the honor to transmit herewith a table of distances between certain military posts in Arizona, and certain places in Arizona,

California, Nevada, and New Mexico, and prepared by Lieut. E. D. Thomas, Fifth Cavalry, acting engineer officer, Department of Arizona.

As this table represents a portion of Lieutenant Thomas's work during the past year, I have to request that it be appended to my annual report.

Very respectfully, your obedient servant,

J. C. MALLERY,
First Lieutenant of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

TABLE.

From Prescott, Ariz., to—	Miles.	Route traveled.
Camp Apache, Ariz	202½	Via Camp Verde and Mogollon Mountains.
	269½	Via Camp Verde, Stoneman's Lake, Sunset Crossing, ambulance and freight road.
Camp Bowie, Ariz	332	Via stage road and Tucson.
Ehrenberg, Ariz	197	Via freight road.
	192	Via Wickenburgh stage road.
	166	Via Skull Valley and Gilson's ranch, ambulance route.
Camp Grant, Ariz	343	Via Tucson, stage and ambulance road.
	319	Via Black Cañon and Phœnix, ambulance and freight road.
Camp McDowell, Ariz	102	Via Black Cañon.
Camp Mojave, Ariz	165	
Phœnix, Ariz	143	Via Wickenburgh, (old road.)
	98	Via Black Cañon, (new road.)
	114	Via new road and Skull Valley stage and ambulance route.
	160	Via heavy-freight route.
Pima Agency, Ariz	151	Via stage and ambulance route.
	127	Via Black Cañon and Phœnix, ambulance route.
Pioche, Nev	434	Via Cerbat, Mineral Park, and Saint George.
Saint George, Nev	350	
Sacramento, Cal	831	Via Dos Palms and Los Angeles.
San Bernardino, Cal	365	Via Dos Palms.
Camp San Carlos, Ariz	422	Via Tucson, ambulance route.
	269	Via McDowell and Old Camp Grant, not traveled.
San Diego, Cal	530	Via Maricopa Wells, stage and ambulance route.
San Francisco, Cal	855	Via Dos Palms and San Bernardino, ambulance route.
San Pedro, Cal	455	Do.
San Pedro, Ariz	284	
Santa Fé, N. Mex	524	Via Sunset Crossing and Wingate.
Stockton, Cal	783	Via Dos Palms and Los Angeles.
Tucson, Ariz	248	Via stage road.
	225	Via Black Cañon, Phœnix, and Sacaton, ambulance route.
Fort Union, N. Mex	624	
Camp Verde, Ariz	42½	Via Copper Canon, ambulance and freight route.
Fort Whipple, Ariz	1½	
Wickenburgh, Ariz	87	Via old road.
	65	Via stage road, Skull Valley ambulance route.
Willow Grove, Ariz	85	
Wilmington, Cal	450	Via Dos Palms and Los Angeles.
Wingate, N. Mex	286	Itinerary of Col. R. I. Dodge, Twenty-third Infantry, odometer measurement.
Fort Yuma, Cal	304	Via Maricopa Wells.
Zuñi, N. Mex	240	Via Sunset Crossing.

From Camp McDowell, Ariz., to—	Miles.	Route traveled.
Camp Apache, Ariz	31½	Via Camp Verde.
Camp Bowie, Ariz	232	
Indian Reservation, Colo	255	Stage, ambulance, and freight route.
Date Creek, (old camp)	110	Ambulance and freight route.
Ehrenberg, Ariz	210	
Florence, Ariz	55	Do.
Camp Grant, Ariz	243	Via Tucson.
Goodwin, (old camp)	267	Via Florence and Desert Road, Tucson and Tus Alamos, upper crossing San Pedro.
Hardyville, Ariz	261	Via Black Cañon and Prescott, ambulance, stage, and freight route.
Camp Lowell, Ariz	134	Ambulance and freight route.
Maricopa Wells, Ariz	45	Do.
Camp Mojave, Ariz	267	Via Black Cañon and Prescott, ambulance and freight route.
Phœnix, Ariz	27	Ambulance and freight route.
Prescott, Ariz	102	Via Black Cañon.
	141	Via stage route.
San Carlos, Ariz	297	Via Tucson and Camp Goodwin.
Tucson, Ariz	127	Via Florence and Desert Wells, ambulance and freight route.
Camp Verde, Ariz	99	Via Black Cañon, Antelope Springs, and Copper Cañon, ambulance and freight road; new route.
Fort Whipple, Ariz	101½	Via Black Cañon, ambulance and freight route.
	142½	Stage route.
Wickenburgh, Ariz	83	Stage, ambulance, and freight route.
Fort Yuma, Cal	222	Do.

Itinerary of route from Camp Verde, Ariz., to Camp Apache, Ariz.

	Miles.
Camp Verde to Clear Creek	4
Clear Creek to Cedar Tanks, sign-board, wood and grass	16
Cedar tanks to Baker's Springs, sign-board, wood and grass	12
Baker's Springs to General Springs, sign-board, wood and grass scarce	12
General Springs to Don Robert's Springs, sign-board, wood and grass scarce	5
Don Robert's Springs to Camp Adam, sign-board, wood and grass	6
Camp Adam to Dead Shot Creek, signboard, wood and grass scarce	8
Dead Shot Creek to Layuna, (sign-board down,) wood and grass scarce	9
Layuna to Foot of Mesa, sign-board, wood and grass scarce	7
Foot of Mesa to Phœnix Park, wood and grass	7
Phœnix Park to Water Holes, wood and grass	18
Water Holes to Clark's ranch, wood and grass	12
Clark's ranch to crossing, wood and grass	14
Crossing to forks of road, wood and grass	6
Forks of road to Camp Apache	24
Total distance	160

REMARKS.

After passing the tree blazed and marked "59½ from Verde," the distances are approximated, as actual measurements stop at that point.

Water is generally found about 8 miles from Baker's Spring, in a creek near remains of a hut.

From that point, until Dead Shot Creek is passed, is the softest portion of the road. If no water is found at Camp Adam, where the creek crosses the road, it can be found down in the cañon to left of the road.

About midway between Phœnix Park and the Water Holes there is a sign-board, marked "Water," to left of the road.

The Water Holes are to the right of the road about a mile.

Between Clark's ranch and crossing, about 10 miles out, water is found in ravine to left of road, sign-board on tree.

From San Carlos, Ariz., to—	Miles.	Route traveled.
Camp Apache, Ariz	100	Via Goodwin, ambulance and freight route.
	65	Trail.
Grant Camp, Ariz	100	Ambulance and freight road.
Camp McDowell, Ariz	297	Via Tucson and Camp Goodwin, ambulance and freight route.
Maricopa, Ariz	284	Ambulance and freight road.
Prescott, Ariz	411	Via Tucson, ambulance route.
Tucson, Ariz	186	Do.
Yuma, Cal	425	Do.
Camp Bowie, Ariz	115	Do.
Camp Mojave, Ariz	587	Via Tucson stage route, ambulance route.
Camp Bowie to Camp Grant, Ariz.	45	Ambulance and freight road.

From Tucson, Ariz., to—	Miles.	Route traveled.
Camp Apache	225	Via Grant and Old Camp Goodwin, ambulance and freight road.
	205	Via Old Camp Goodwin.
Camp Bowie	105	Ambulance and freight road.
Camp Colorado	343	Via Ehrenberg, ambulance, stage, and freight route.
Ehrenberg	303	Via Wickenburgh, stage route.
Florence	72	Desert Road, ambulance and freight road, stage route.
Camp Grant	116	Ambulance and freight road.
Hardyville	437	Via Prescott.
Camp McDowell	127	Via Florence and Desert route, ambulance and freight road.
Camp Lowell	7	
Maricopa Wells	98	Stage route.
Camp Mojave	441	
Prescott	225	Via Black Cañon.
San Carlos	186	Via Grant.
Camp Verde	223	Via Black Cañon.
Wickenburgh	176	Stage and ambulance route.
Yuma	275	Via Maricopa Wells, stage route.

REMARKS.—Data obtained from records of engineer office, Department of Arizona, and from actual measurements by chain and odometer.

E. D. THOMAS,
First Lieutenant Fifth Cavalry, A. D. C.,
Acting Engineer Officer, Department of Arizona.

PRESCOTT, ARIZ., *July* 8, 1876.

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